Environmental Reconstruction at Island House, Laugharne

Final Report January 2023 (draft)

Report commissioned by Island House Restoration Ltd.

Image credit: http://islandhouse.wales/#about

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1) Introduction

The principal aim of the project is to establish an environmental history for the Island House site in Laugharne (SN301107) from two interconnected perspectives: (i) channel dynamics of the River Coran, and (ii) sedimentation of the tidal inlet linked to the River Taf estuary. Although extensive archaeological surveys have been conducted in Laugharne, particularly linked with the castle site, there is not an equivalent depth of knowledge regarding the site's broader environmental history. To build a more complete history of Laugharne, and how its development has potentially been influenced by interactions with the River Coran and the tidal inlet (linked to the Taf Estuary), there are several key questions that need addressing:

a) Murphy's 2021 report for Dyfed Archaeological Trust suggests that the tidal inlet at Laugharne may have been bounded on both banks by operational wharfs and quays in the 14th century. Is there geomorphological/sedimentological evidence to support this conjecture?
b) The name 'Island House' implies that the site was once an island, possibly linked with a crossing point of the tidal inlet and/or River Coran. If this is the case, when did the island cease to function as such?
c) When did the tidal inlet silt up and over what timescale? Was the siltation driven by terrestrial or estuarine sediment sources, or a combination of both?

Following the introduction, this report is divided into three main sections covering (1) field and laboratory methods, including a summary of site visits, (2) results of the GPR, coring, sediment logging and ^{14}C dating programmes, and (3) an interpretation and environmental reconstruction of the Island House site based upon our own data and correlations with published environmental/climate change records.

2) Field and laboratory methods including data processing

Table 1 provides a summary of the work undertaken during each of the seven site visits. The project was initially scheduled to be completed within 6 months, but delays were introduced due to difficulties in securing the services of a drillings contractor that could provide intact cores for logging and dating.

Table 1: Summary of site visits

Dates	Work undertaken	Comments
21st July 2021	Initial site meeting with Stephen Kirkwood	
18th August 2021	Sediment logging	Planned coring work did take place as the designated contractor was unable to undertake the work.
14th October 2021	GPR Survey of salt marsh, Island House site, Cors Field play area, and Clifton Street building plot	16 survey lines totalling 780 m
15th/16th November 2021	Coring with Samson Drilling	4 x cores recovered from saltmarsh (x2) and Clifton Street Building plot (x2)
5th April 2022	GPR Survey of salt marsh, Island House site, Cors Field play area, and Clifton Street building plot	18 survey lines totalling 920 m
19th/20th July 2022	Coring with QuantumGeotech on saltmarsh and at Clifton Street building plot	3 x cores recovered from saltmarsh (x2) and Clifton Street Building plot (x1)
16th December 2022	GPR Survey of salt marsh, Island House perimeter wall, Cors Field play area, and Clifton Street building plot	27 survey lines totalling 1370 m

2.1 Sediment logging

Four exposed sediment sections within the footprint of the Island House site were logged in August 2021 and November 2021 (Figure 1). Log 1 comprised a sediment section exposed by Dyfed Archaeological Trust's excavation work; it was initially described in their 2020 report (DAT, 2020). Log 2 was located on the western margin of a small watercourse that formerly ran beneath Island House. Logs 3 and 4 were taken from excavated pits.

At each log site, distinct sediment units were identified and their characteristics described in terms of grain size, colour, sediment sorting, the nature of matrix/grain contacts, and the presence of macrofossils / organic material. This systematic logging process enabled direct comparison of sediment sequences at different localities and facilitated interpretation of the sediment accumulation story at the site (from natural fluvial/marine processes and/or human activity). Each sediment profile was carefully examined for the presence or organic material (e.g. wood, charcoal, shell fragments) that could be used for subsequent radiometric carbon-14 dating (^{14}C) (see section 2.3).

Figure 1: Location of sediment logs within the Island House boundary (Image from Bing Maps)

2.2 Coring

In November 2021 a 2-day coring programme was undertaken at 4 locations (Figure 2). The purpose of this programme was to recover sediment for logging and the recovery of material for ^{14}C dating (see section 2.3). Core 1, on the saltmarsh, was located with the aim of recovering an estuarine record of sedimentation, whereas core 2 was located to recover a combination of fluvial (R. Coran) and estuarine activity. Cores 3 and 4 at the Clifton Street building plot site were located sufficiently upstream to just contain a record of fluvial (R. Coran) activity.

Due to poor sediment recovery and the disturbed nature of several cores, a second drilling programme was undertaken with QuantumGeotech in July 2022 at the same locations. Three cores were recovered and logged (core locations 1-3; Figure 2) using the same protocol as outlined in section 2.1, and carefully examined for the presence or organic materials (e.g. wood, charcoal, shell fragments) that could be used for subsequent radiometric carbon-14 dating (^{14}C).

A)

B)

Figure 2: Location of coring sites initially drilled in November 2021 and then subsequently redrilled in July 2022: A) salt flats, and B) Clifton Street. Base image from Bing Maps.

2.3 Radiometric ^{14}C dating

Radiocarbon dating uses the decay of a radioactive isotope of carbon (^{14}C) to date materials such as wood, bones, seeds, shells etc. With a half-life of 5,700 ± 30 years, ^{14}C can be used to determine ages up to ~ 50,000 years before present.

Cosmic rays from the sun interact with nitrogen (N) in the Earth's atmosphere leading to the production of ^{14}C. Living plants and animals absorb atmospheric ^{14}C via photosynthesis and respiration during their lifetime. Following death, ^{14}C decays at a known rate back to nitrogen atoms (^{14}N). By measuring the residual ^{14}C content in dead plant/animal matter, it is possible to determine how long ago the animal or plant died. The technique is robust and widely used by scientists interested in reconstructing past environments.

In marine / estuarine environments ^{14}C dating is still applicable, but it is complicated by the so-called Marine Reservoir Effect (MRE). Marine plants and animals absorb ^{14}C from sea water which has a different carbon content to the atmosphere, this can lead to terrestrial and marine organisms of equivalent ages having a difference of about 400 radiocarbon years (Beta Analytic, 2022). The MRE is significant for this study because organic samples were dated from both terrestrial and marine /estuarine sediments, therefore, a correction has been applied to all dates determined from marine shells recovered from cores 1 and 2 (Figure 2) and from sediment log 1 (Figure 1).

2.4 GPR surveys

Ground penetrating radar is a non-destructive geophysical method that employs pulses of electromagnetic energy to image features in the top tens of metres within Earth's subsurface. To image the subsurface, a GPR system exploits varying dielectric properties of subsurface materials which influence the transmission and reflection the electromagnetic energy.

Typically, a transmitting antenna sends a pulse of energy into the subsurface at a particular frequency, commonly between 10 MHz and 2.6 GHz, and the receiving antenna then records the energy that is reflected back to the surface. The antennae, separated by a fixed distance, are then moved along a profile line to record an image or *radargram* of spatial changes in reflected energy over time (equivalent to depth) in the subsurface. Because the transmitted pulse of energy decreases with depth, through reflections or loss, the depth to which the radargram may extend is conditioned by the GPR system itself and the properties of the subsurface. Higher frequency energy pulses do not penetrate as far as low frequency pulses; also, for materials with high electrical conductivity (e.g. saline salt marsh environments), energy is more rapidly lost and the penetration depth of the GPR is reduced.

However, there is a trade-off between frequency and penetration: low frequency pulses may penetrate deeper into the subsurface, but they are less likely to exhibit energy reflections for small-scale changes in dielectric properties and so their resolution is reduced. Low frequency GPR surveys offer a broad context to a site's subsurface, but may not be suited for identification of fine scale features or structures in the subsurface. Higher frequency surveys, in contrast, will better image small-scale differences in the subsurface, but only for a shallow penetration depth. Importantly, the reflected energy recorded by the receiving antenna can be influenced either by materials with high electrical conductivity close to the survey line (e.g. metals objects such as road signs, benches, parked vehicles, buried pipes), or by external sources of electromagnetic energy (e.g. buried or overhead power-lines).

2.4.1 Field method

Ground penetrating radar (GPR) data were collected with a Mala ProEx system, using 50 MHz and 100 MHz unshielded rough terrain antennae, and 250 MHz and 500 MHz shielded sledge antennae. The antennae were kept co-polarised with a common offset; the lower frequency surveys (50 & 100 MHz) used a parallel endfire orientation while the higher frequency (250 & 500 MHz) used a parallel broadside configuration.

The GPR survey work was conducted over three site visits and targeted five localities (Figure 3):

1) The saltmarsh (profiles 1 & 2)
2) At Cors Field play area (profiles 3 & 4)
3) At Clifton Street building plot (profiles 5 - 8)
4) On the external perimeter boundary (town wall) of Island House (profiles 9 - 12).
5) Within the footprint of the Island House site (profiles 13-15)

In total 61 GPR profiles were surveyed totalling 3,070 m (Table 2). Each GPR profile was surveyed twice using two frequencies (50 MHz & 100 MHz, or 250 MHz & 500 MHz). In addition, a 100 MHz velocity survey was conducted at each of the three locations to enable more accurate calibration of survey depths.

Table 2: Summary of GPR surveys.

<table>
<tr><th>Survey date</th><th>Number of profiles</th><th>Approximate total profile length (m)</th><th>Antennae frequency (MHz)</th><th>Locations</th></tr>
<tr><td rowspan="2">14/10/21</td><td rowspan="2">16</td><td rowspan="2">780</td><td>50
100</td><td>Salt marsh
Island House compound
Cors Field</td></tr>
<tr><td>100</td><td>CMP data collections</td></tr>
<tr><td rowspan="2">5/4/22</td><td rowspan="2">18</td><td rowspan="2">920</td><td>250
500</td><td>Salt marsh
Island House compound
Cors Field
Clifton Street plot</td></tr>
<tr><td>100</td><td>CMP data collections</td></tr>
<tr><td>16/12/22</td><td>27</td><td>1370</td><td>250
500</td><td>Salt Marsh
Island House perimeter walls
Cors Field
Clifton Street plot</td></tr>
</table>

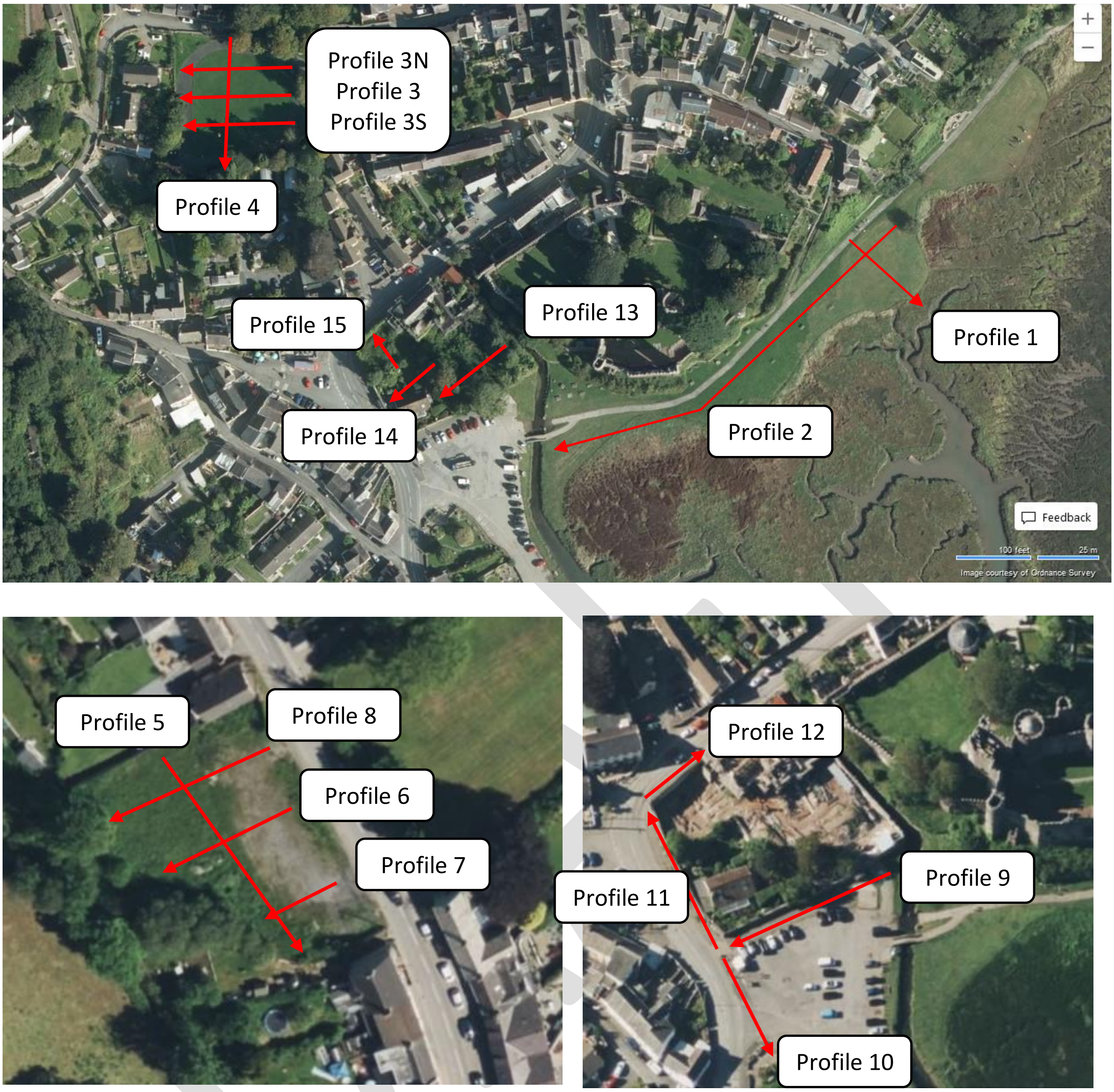

Figure 3: Location of GPR survey profiles on the salt marsh (profiles 1 & 2), at Cors Field play area (profiles 3 & 4), at Clifton Street building plot (profiles 5-8), and on the external perimeter boundary (town wall) of Island House (profiles 9-12), and within Island House (profiles 13 – 16).

2.4.2 Determining GPR wave velocity

As a first order estimate of integrated subsurface radar wave velocity (required to convert signal time on radargrams to depth in meters), central mid-point (CMP) surveys were undertaken adjacent to the Laugharne Castle wall near where the River Coran emerges at the estuary, at the Cors Field play area, and at the Clifton Street building plot. The CMP used 100 MHz unshielded paddle antennae (oriented perpendicular broadside).

Due to the nature of the ground, and the additional complexities incurred by surface features (e.g. metal framed park benches, overhead power/communication cabling), CMPs were observed to less effective than anticipated either at coarser resolution or at particular sites. (Figure 4).

Nonetheless, analyses of the CMP data revealed subsurface radar wave propagation velocities estimated to be between ~0.055 m/ns and 0.07 m/ns. Commonly cited velocities (v) for topsoils, silts and wet sands are ~0.07 m/ns, and for dry to saturated clays are around 0.06 – 0.11 m/ns. Fresh water has a radar propagation velocity of ~0.03 m/ns, and for saline (marine) water v = 0.01 m/ns. Consequently, water-rich or saturated soils silts and clays can exhibit velocities of < 0.05 m/ns. Here, to estimate depth on the radargrams, we used a vertically continuous velocity of 0.06 m/ns, acknowledging our vertical positioning contains some uncertainty (± 6 – 10%) associated with vertical and horizontal heterogeneity in dielectric properties of a complex subsurface that were not resolved.

2.4.3 GPR data processing

To produce the radargrams (2 dimensional plots of signal response over distance), the following sequence of standard signal processing steps was applied to enhance visual interpretability:

- Time zero: to remove preceding data ahead of subsurface signal for each trace;
- Time cut: to remove data from time/depths below typically interpretable signal limits for each trace;
- DC shift and Dewow: to normalise each individual trace to a zero datum and remove very low frequency signal drift (or 'wow');
- Butterworth bandpass filter: to remove low and high frequency noise across all traces;
- Stolt migration with a velocity of 0.06 m/ns: a data processing step that seeks to move apparent location of signal to its true location, and collapse the appearance of hyperbolae;
- Gain function: to enhance signals that are decreased due to energy attenuation with depth, using either a normalised automatic gain function or assuming an energy decay function;
- Background removal: to remove consistent horizonal background (noise) signals; this stage was applied where refractive multiple returns were problematic;
- Surface-parallel smoothing: to reduce the noise within the radargram and amplify coherence of subsurface quasi-horizontal and dipping signals;
- Topographic correction: revising the radargram plot to account for land surface elevation to aid interpretation, where differential (centimetre precision) location data was collected.

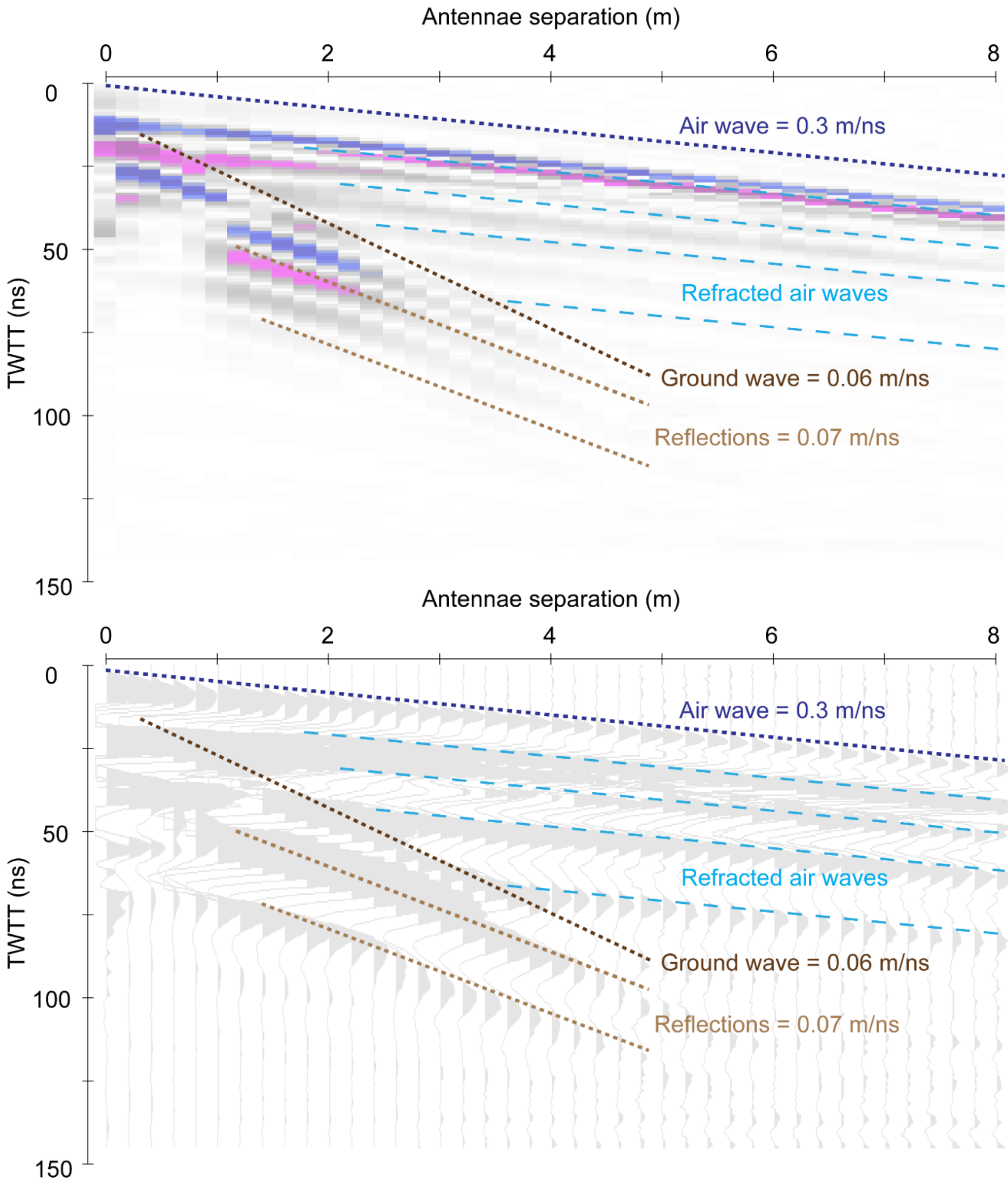

Figure 4: Central mid-point (CMP) velocity analysis highlighting the parallel signal intensity (top) and wiggle-mode (bottom) plot interrogation for a first-order estimate of near surface radar wave propagation velocity.

3) Results for GPR, dating and coring programmes

3.1 GPR surveys

3.1.1 Radargram legend

Figure 5 summarises the standard GPR data processing workflow followed to produce all radargrams presented in this report. For all radargrams, a plot of the processed data is presented next to an interpretive schematic. For the latter 'interpretation' plots, the land surface is shown in blue, patterns associated with surface features are shown in solid black and with dashed black lines, the transition identified as 'signal extinction' near the surface is shown by a pink dashed line, with additional indicators associated with subsurface dielectric property contrasts with a pink solid line. Subsurface reflection signals that probably indicate sedimentary structures are shown with brown dashed lines. However, there is a degree of subjectivity in defining some of these reflectors due to reduced level of signal coherence caused by saline or clay-rich sub-surface ground conditions, and the high number of metal objects creating interference.

3.1.2 Profile 1: Castle to sea

The profile oriented south-east, from the castle walls to the salt-marsh/estuary, consistently showed across both antennae 50 MHz and 100 MHz frequencies, evidence of a near-surface sediment unit that extinguished signal (Figures 6 and 7); this extended to ~ 60 ns (~2 m) depth. In the lower frequency surveys, a number of multiple reflections (or resonant scattering) were observed in the near-surface, but these are not indicative of discreet sediment units. Strong dipping seaward reflectors evident in the unshielded radargrams were absent in the higher frequency survey (Figure 7); the combination of multiple parallel reflection signatures, and a first-order velocity assessment, suggest these were caused by offline returns from the castle wall, the footpath, foundations, or a buried electrical cable present at the start of the survey profile. The landward dipping reflection signatures found closer to the estuary are likely a result of offline returns from high [saline] water content in the sediment or the estuary water itself.

The shielded antenna surveys highlighted a 15 m wide zone of apparently disturbed and reworked ground in the upper sediment unit, likely containing a number of small-scale point source reflectors (e.g., rubble, gravels etc.). This zone was evident ~ 10 m from the castle wall, and extended to the break of slope descending to the salt marsh. However, due to the presence of metal-framed park benches close to the survey line (and elsewhere in the broader locality) it is likely some of the 'disturbed ground' signal may be caused by offline returns.

The elevated subsurface salinity and high clay content in the saltmarsh sediments, and the close proximity of saline estuary water, was evident in the radargrams: e.g., increased noise at depth in the 250 MHz survey, dampening of signal in the 250 MHz and 500 MHz surveys (in the uppermost 1 m) (Figures 8 and 9). This latter diagnostic was particularly evident in the second set of higher frequency surveys, for the ground close to the River Coran, and the section of the profile furthest from the castle.

The sediment transition at ~1 to 2 m below the surface resulted in multiple reflections (or resonant scattering), making determination of signal vs. noise at depths below 2 m challenging. The elevation variation of the transition surface precluded it from being interpreted as a water-table.

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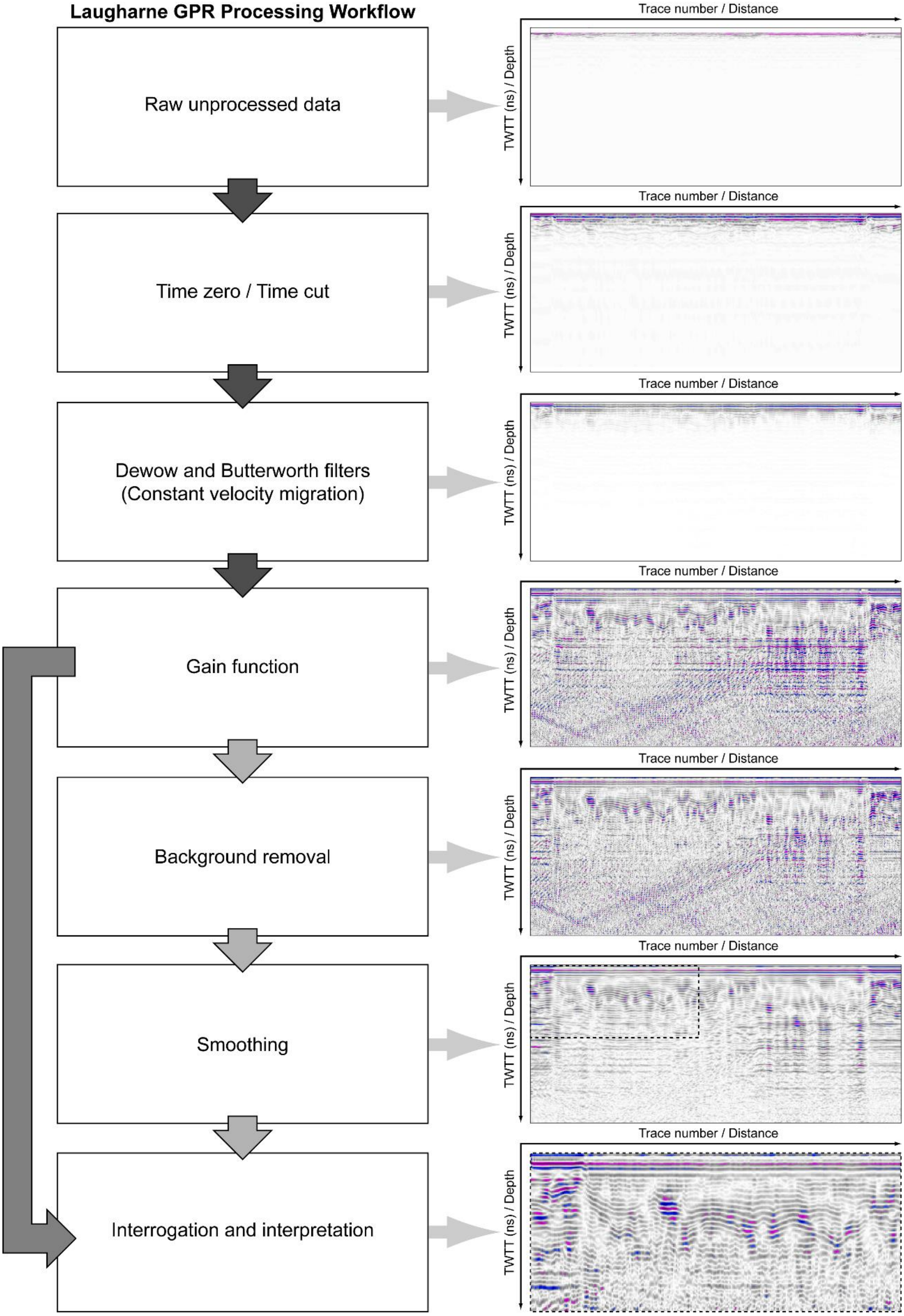


Figure 5: Standard GPR data processing workflow sequence. Note, the migration step is optional, and additional steps of background removal and smoothing are used to enhance visualisation in some instances. Topographic correction was applied to some profiles to aid interpretation.

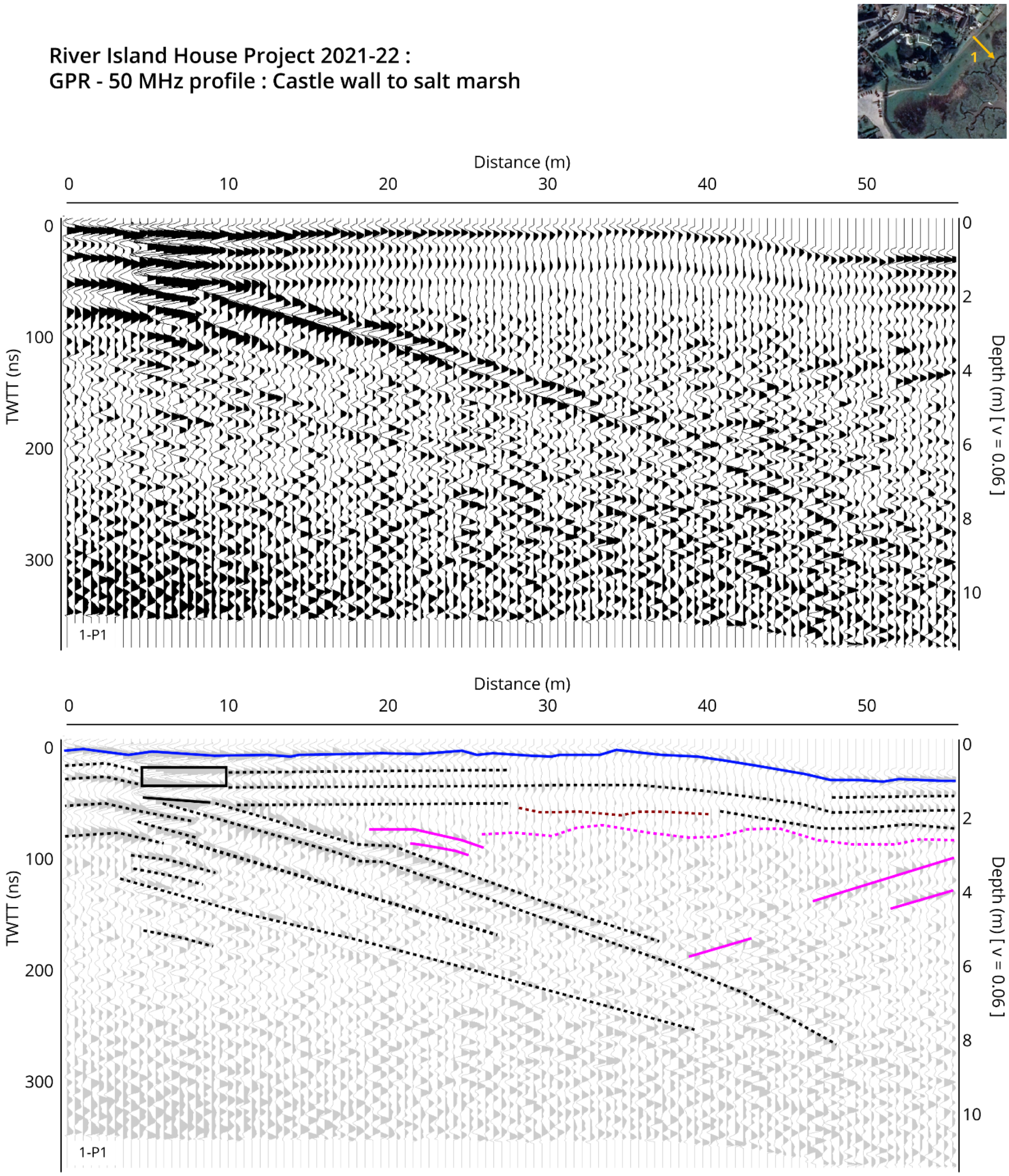


Figure 6: Radargram for Profile 1 between the castle walls and estuary for 50 MHz unshielded antennae (top) and first-pass interpretations (bottom). Position and profile orientation shown in upper inset.

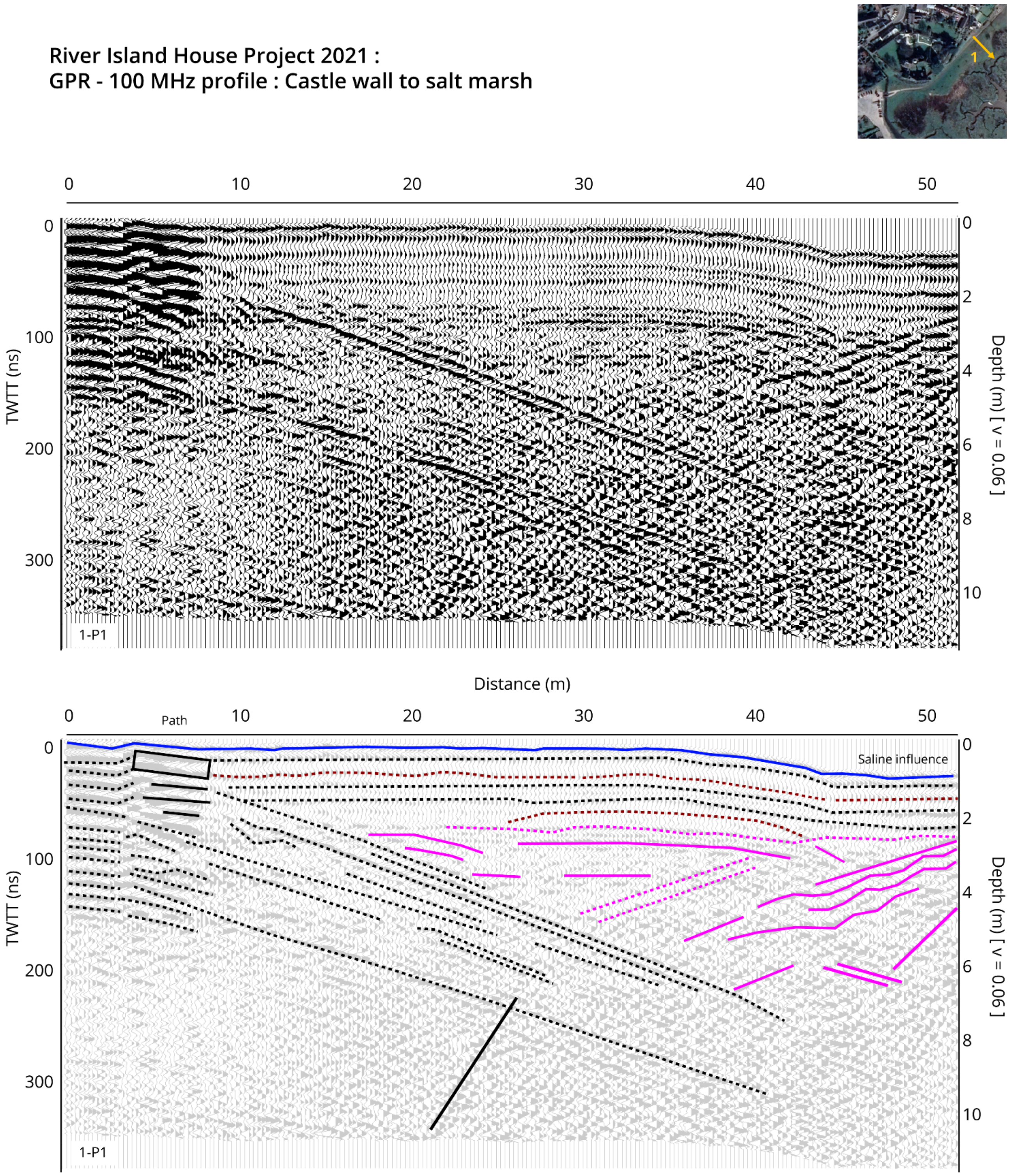


Figure 7: Radargram for Profile 1 between the castle walls and estuary for 100 MHz unshielded antennae (top) and first-pass interpretations (bottom). Position and profile orientation shown in upper inset.

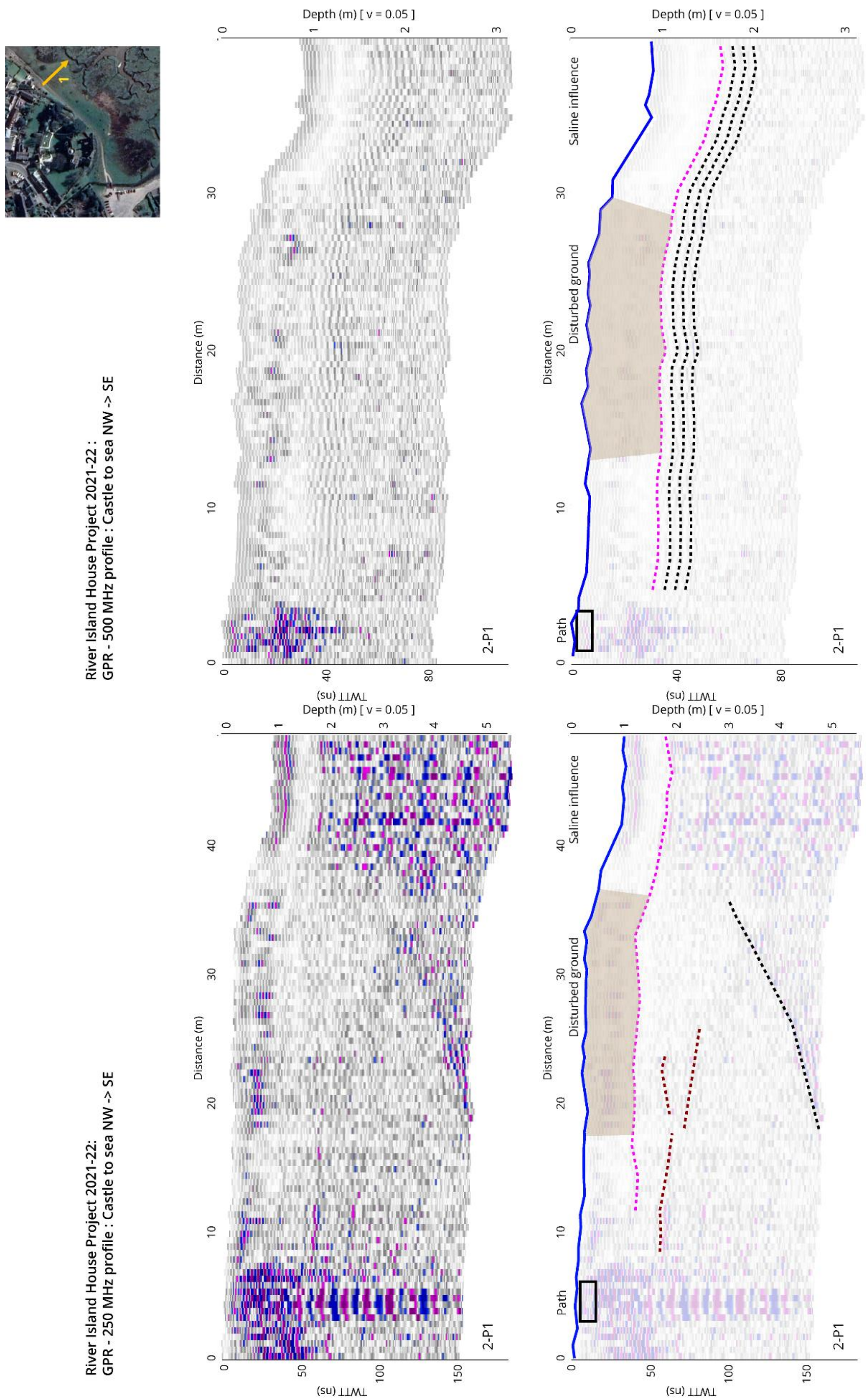


Figure 8: Radargrams and first-pass interpretations for Profile 1 between the castle walls and estuary for 250 MHz (left pair) and 500 MHz (right pair) shielded antennae. A coarse sampling strategy was employed given offline interference highlighted by lower frequency surveys. Position and profile orientation shown in upper inset.

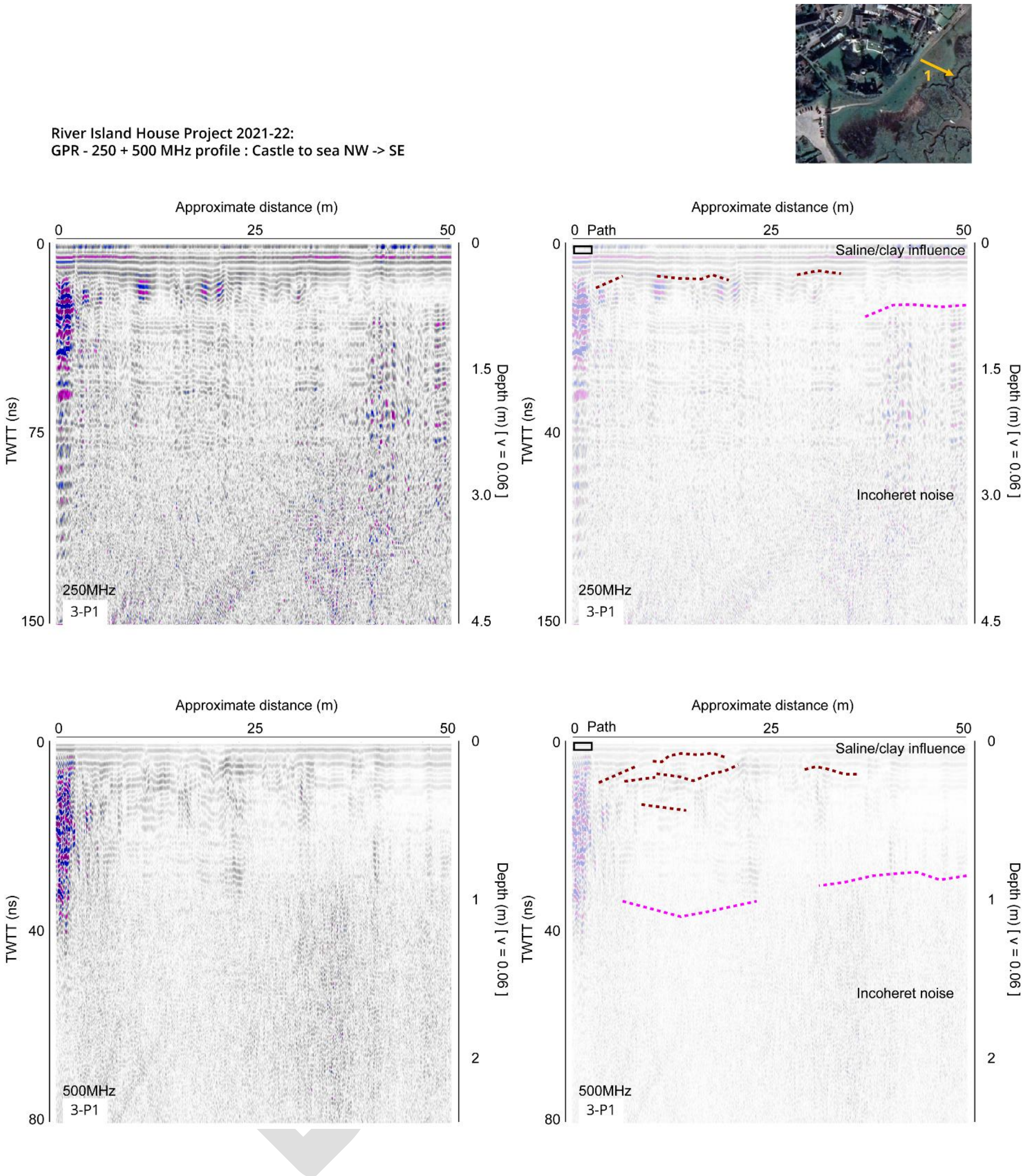


Figure 9: Radargrams and first-pass interpretations for Profile 1 between the castle walls and estuary for 250 MHz (left pair) and 500 MHz (right pair) shielded antennae. A fine sampling strategy was employed given indications of near-surface facies in the coarse surveys. Position and profile orientation shown in upper inset.

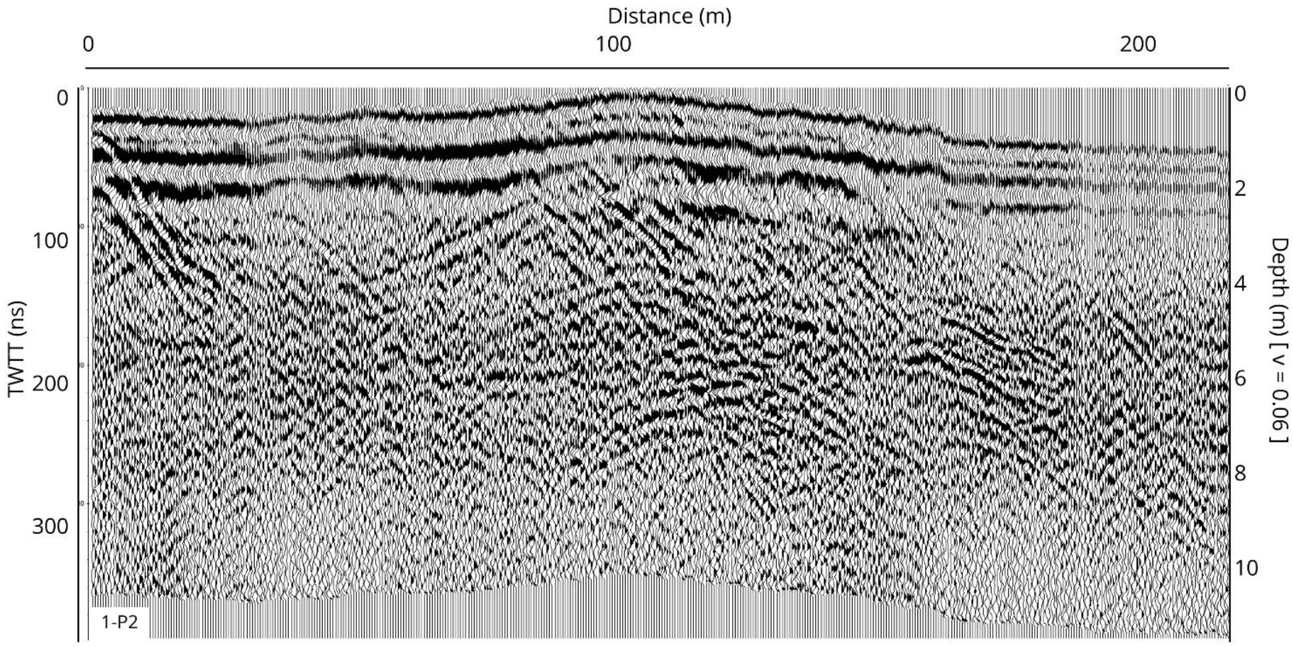
3.1.3 Profile 2: Castle to River Coran (parallel to estuary)

The lower frequency (50 MHz and 100 MHz) profiles show a transition in radargram signature at ~ 60 ns (~2 m) depth (Figures 10 and 11). Multiple reflections (or resonant scattering) were observed in the near-surface. At a distance of ~20 to 40 m along the profile, particularly in the 100 MHz survey (Figure 11), there is evidence some disturbed ground where the profile runs parallel to the castle's outer wall. However, as noted in section 3.1.2, some caution should be applied to this interpretation given the relative proximity of the path, park benches and other man-made features.

The subsurface signatures in the low frequency radargrams are dominated by a number of hyperbola (inverted U-shaped reflectors) present across the entire the profile. Following velocity assessment, these were interpreted as the offline returns emanating from the numerous metal and concrete-mounted park benches that are placed either side of the concrete path.

For the higher frequency surveys (250 MHz and 500 MHz), radargrams revealed a higher salinity or clay-rich sediment unit extending to a typical depth of ~40 ns (~1.2 m), and more clearly identified a zone of potentially reworked and/or disturbed ground (e.g., including rubble, gravels etc.) where the ground rises slightly close to the castle's southern-most extent (Figures 12 - 14). Despite the use of shielded antennae, the disturbed ground in this zone is again influenced by the presence of metal-framed park benches and the footpath.

River Island House Project 2021 :
GPR - 50 MHz profile : Below castle to river



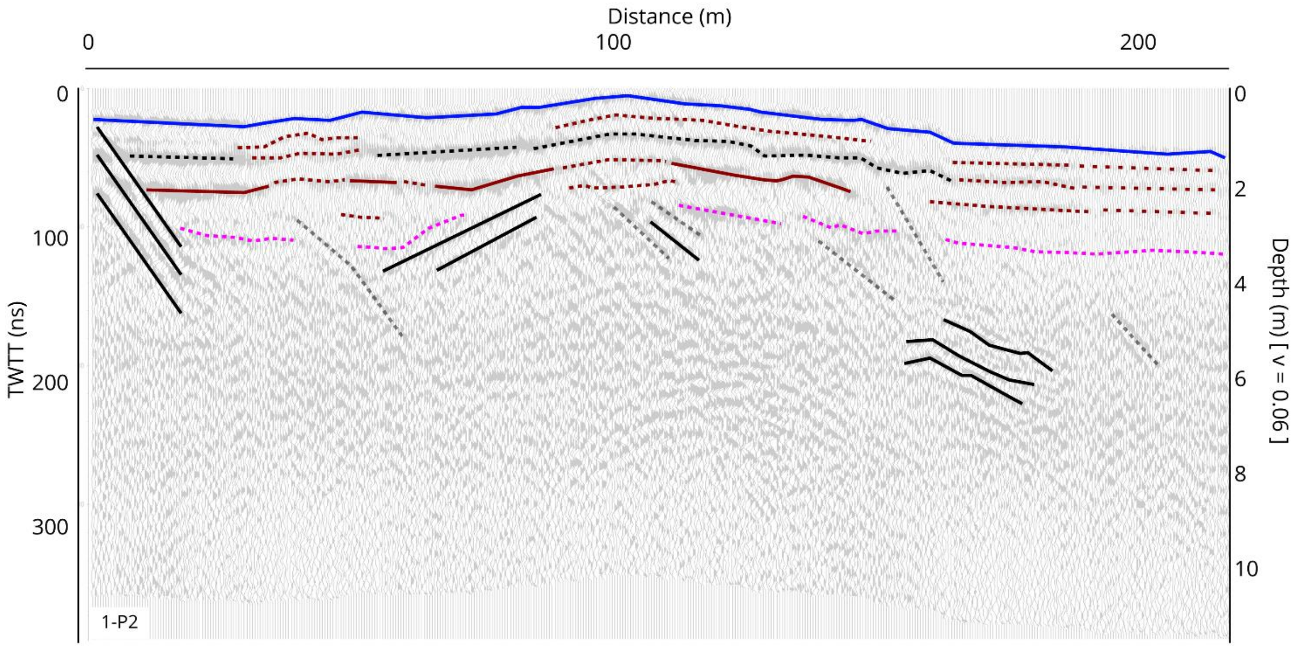


Figure 10: Radargram for Profile 2 south of the castle walls for 50 MHz unshielded antennae (top) and first-pass interpretations (bottom). Position and profile orientation shown in upper inset.

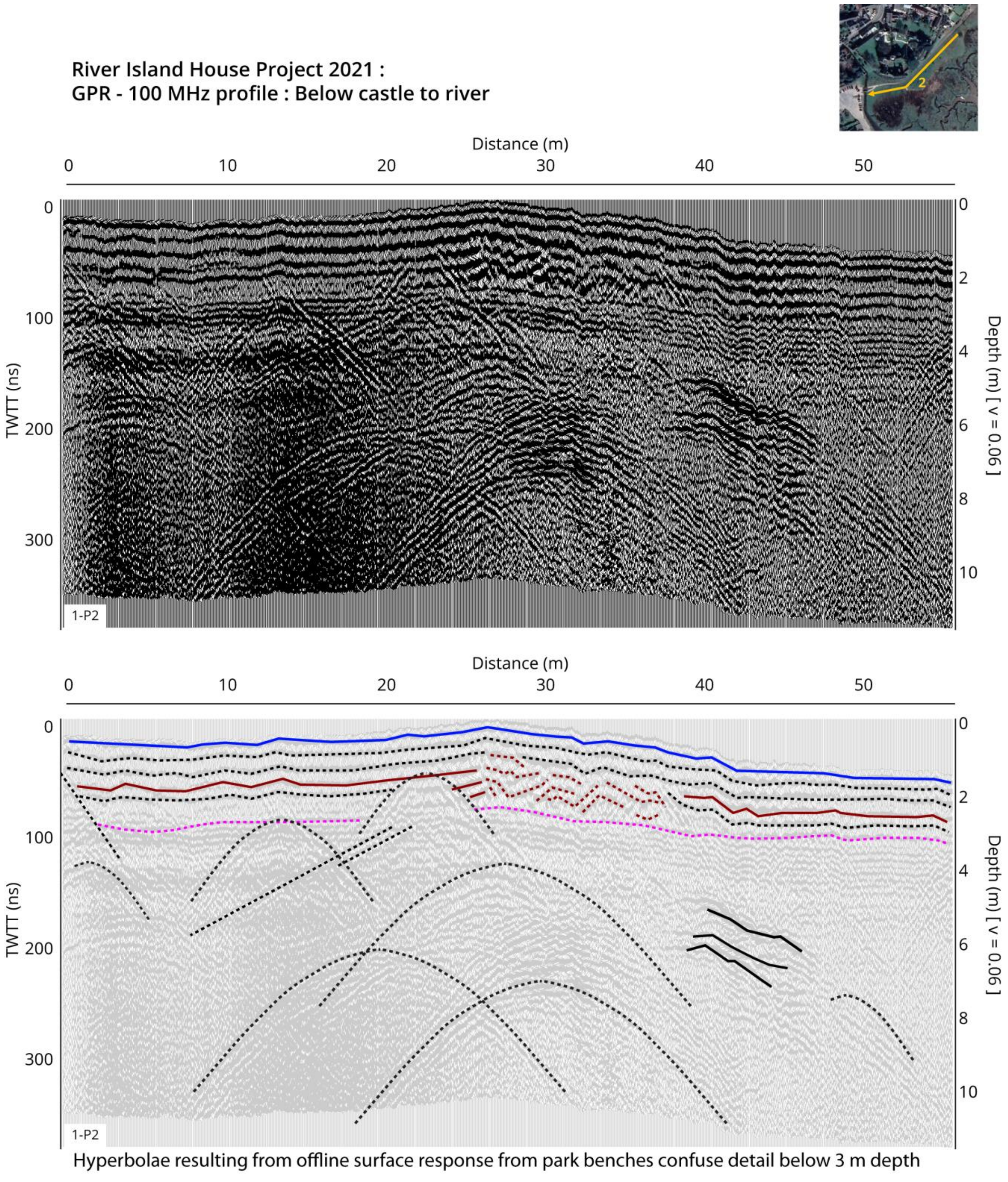


Figure 11: Radargram for Profile 2 south of the castle walls for 100 MHz unshielded antennae (top) and first-pass interpretations (bottom). Position and profile orientation shown in upper inset.

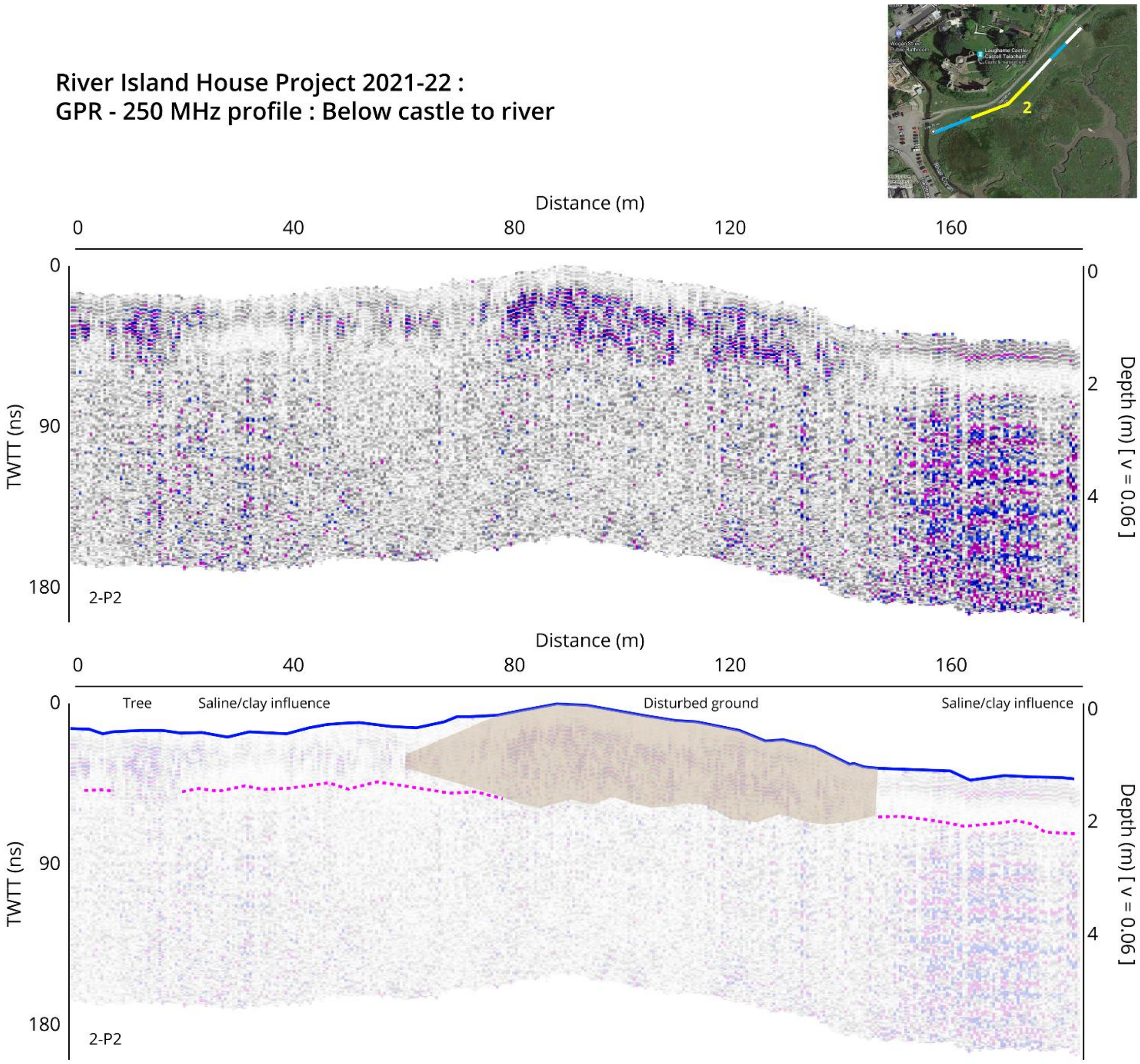


Figure 12: Radargram for Profile 2 south of the castle walls for 250 MHz shielded antennae (top) and first-pass interpretations (bottom). A coarse sampling strategy was employed given offline interference highlighted by lower frequency surveys. Position and profile orientation shown in upper inset.

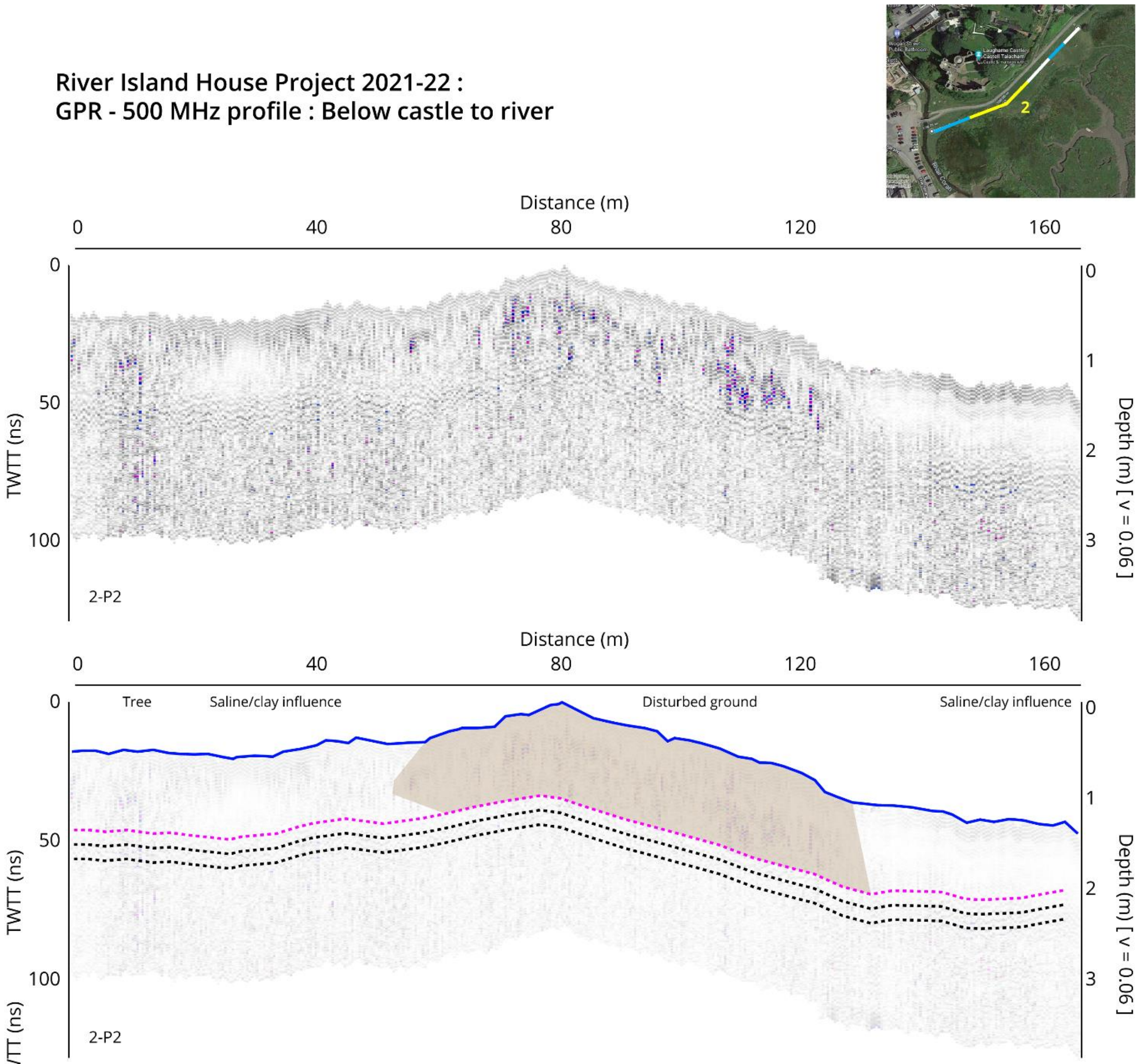


Figure 13: Radargram for Profile 2 south of the castle walls for 500 MHz shielded antennae (top) and first-pass interpretations (bottom). A coarse sampling strategy was employed given offline interference highlighted by lower frequency surveys. Position and profile orientation shown in upper inset.

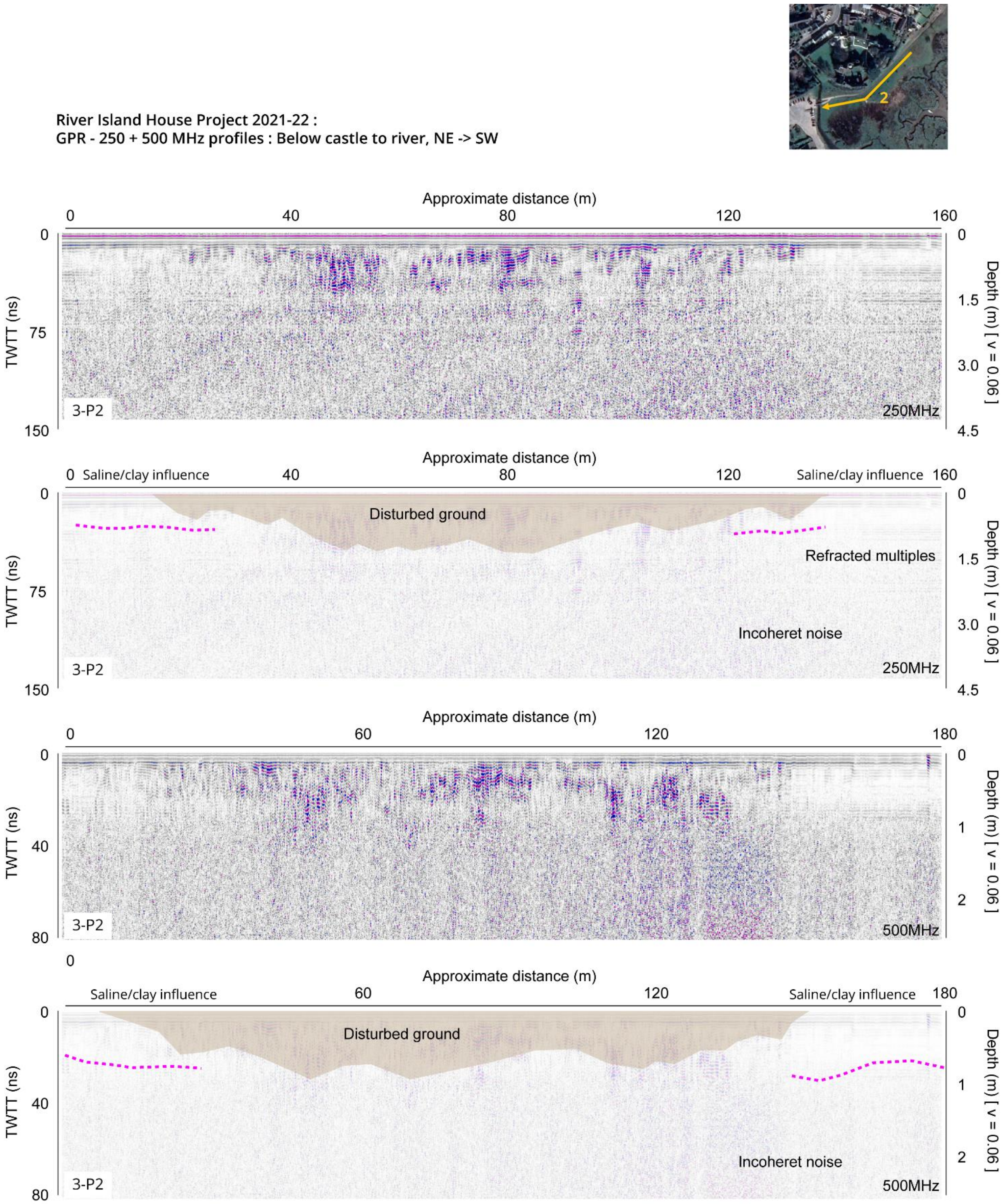


Figure 14: Radargrams and first-pass interpretations for Profile 2 south of the castle walls for 250 MHz (top pair) and 500 MHz (bottom pair) shielded antennae. A fine sampling strategy was employed given indications of near-surface facies in the coarse surveys. Position and profile orientation shown in upper inset.

3.1.4 Profiles 3 and 4: Cors Field play area

The lower frequency unshielded surveys were negatively impacted by the presence of overhead powerlines; these resulted in dominant linear dipping reflectors cross-cutting the radargrams Figures 15-16). The influence of these dominant signatures compromised interpretation of the subsurface stratigraphy, however, the following features are distinguishable: (i) a change in sediment characteristics at a depth of 60 ns to 100 ns (1.8 m – 3 m), and (ii) some subtle sub-horizonal structures in the uppermost 2 m.

The higher frequency surveys (250 MHz and 500 MHz) suggest the subsurface transition was located at 35 ns to 80 ns (≤ 2 m) depth (Figures 17-18). Critically, there was some evidence of subsurface structures to depths of approximately 100 ns (~ 3 m); particularly for the profiles running westwards away from the River Coran. The form of these reflectors is indicative of a former river channel (palaeochannel), suggesting lateral variation in the river's course, perhaps through meandering and/or the confluence of a stream flowing to join the main river.

The second set of high frequency shielded surveys were more conclusive with clear evidence of subsurface sediment structures in the uppermost 40 ns (~ 1.2 m); a suite of indicative sub-horizontal, non-parallel, dipping reflector surfaces was clear, indicating former buried river channels (Figures 19-20). There is some evidence of some localised zones of wet or waterlogged clay-rich sediments. However, combined, these subsurface characteristics may also suggest sequences of 'infill' potentially by anthropogenic influence. Below ~ 1.2 m depth, radar signal was extinguished, suggestive of high water content clays influencing the loss of radar energy in the subsurface at depth.

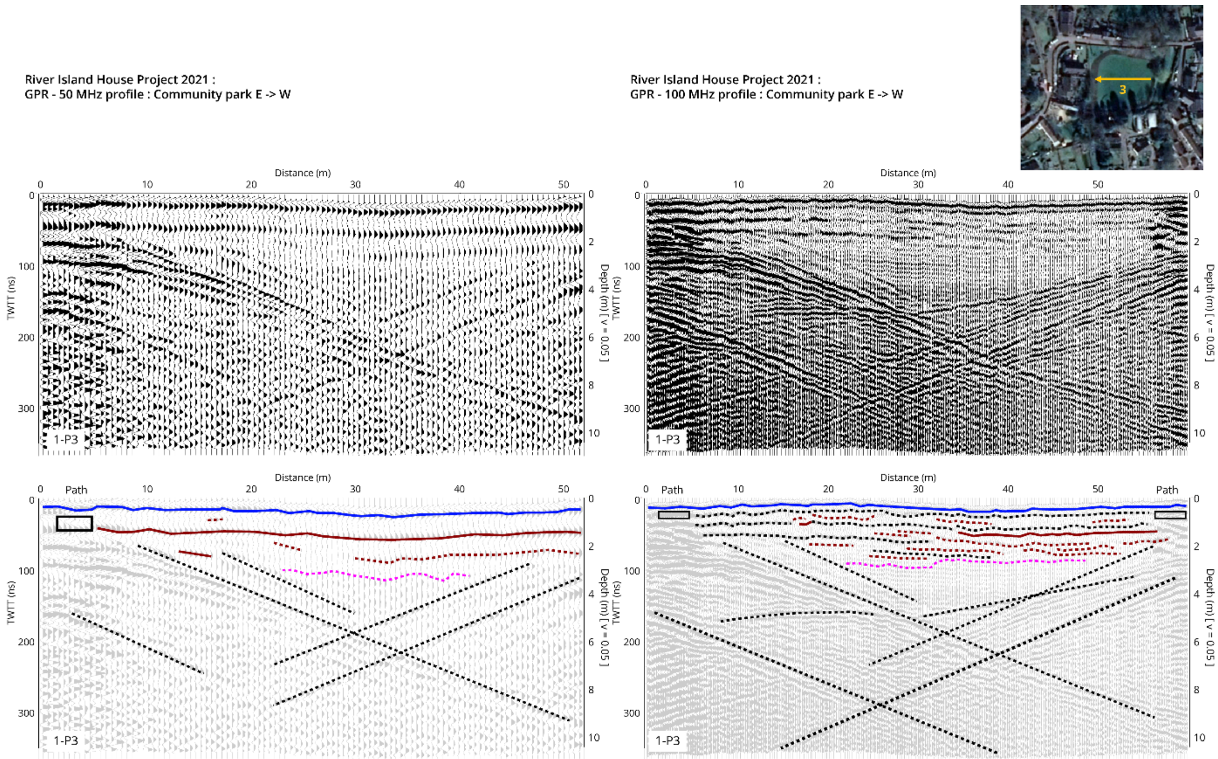


Figure 15: Radargrams and first-pass interpretations for east-west oriented Profile 3 across Cors Field play area for 50 MHz (left pair) and 100 MHz (right pair) unshielded antennae. Position and profile orientation shown in upper inset.

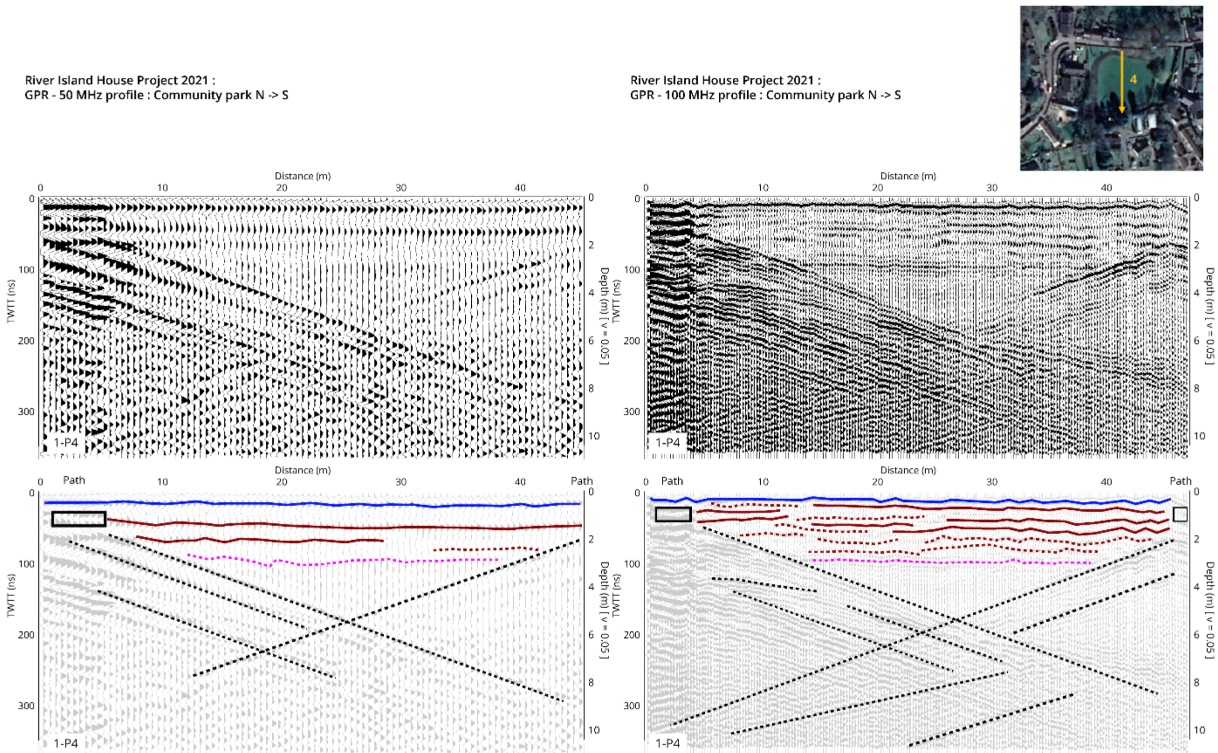


Figure 16: Radargrams and first-pass interpretations for north-south oriented Profile 4 across Cors Field play area for 50 MHz (left pair) and 100 MHz (right pair) unshielded antennae. Position and profile orientation shown in upper inset.

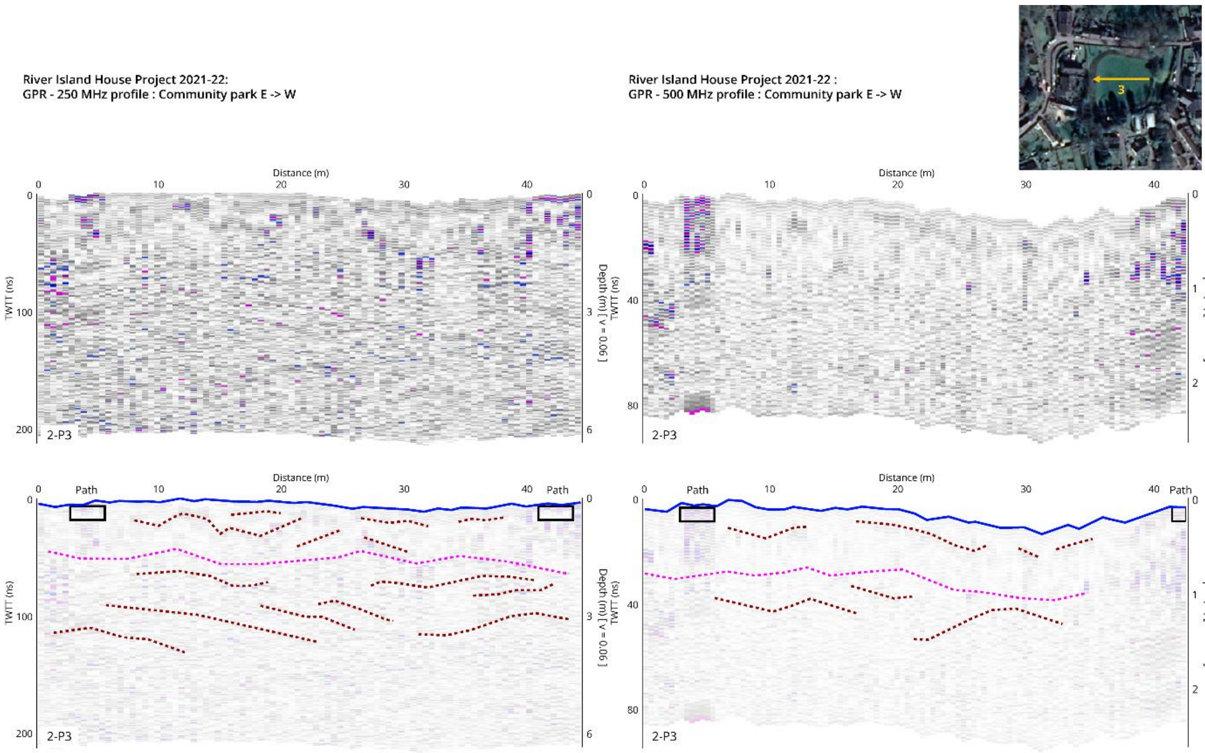


Figure 17: Radargrams and first-pass interpretations for east-west oriented Profile 3 across Cors Field play area for 250 MHz (left pair) and 500 MHz (right pair) shielded antennae. Position and profile orientation shown in upper inset.

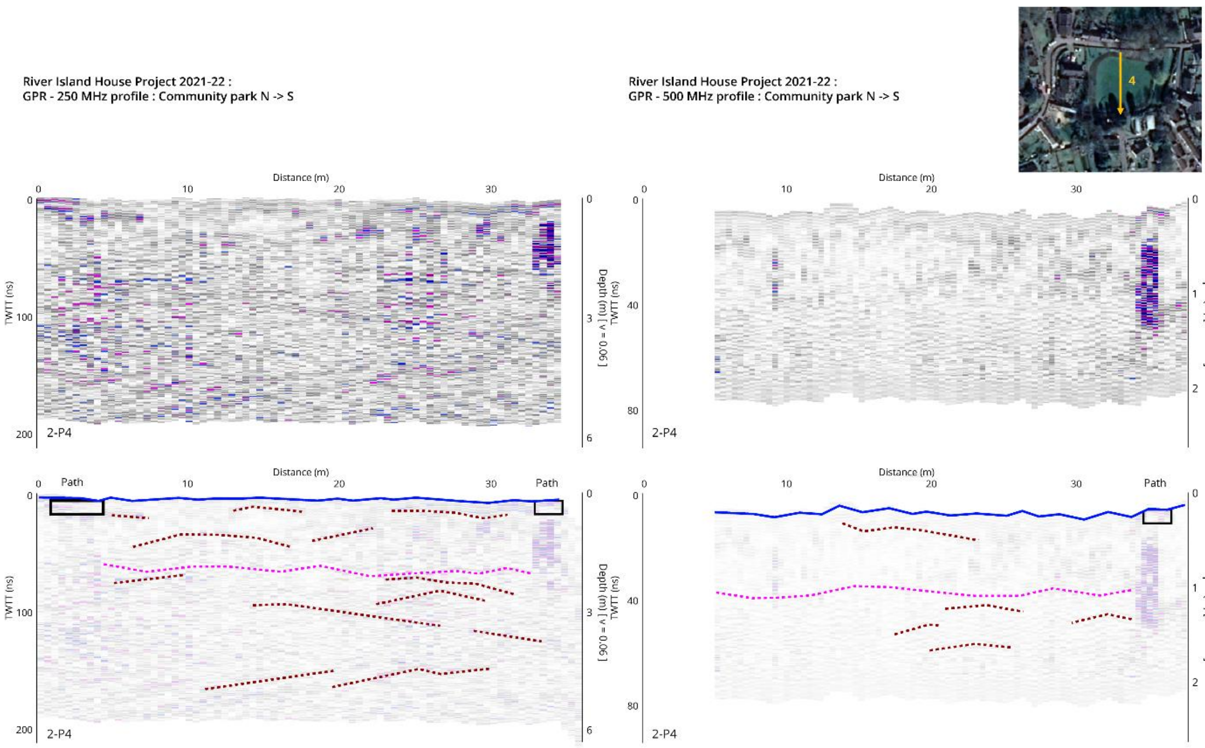


Figure 18: Radargrams and first-pass interpretations for north-south oriented Profile 4 across Cors Field play area for 250 MHz (left pair) and 500 MHz (right pair) shielded antennae. A coarse sampling strategy was employed given offline interference highlighted by lower frequency surveys. Position and profile orientation shown in upper inset.

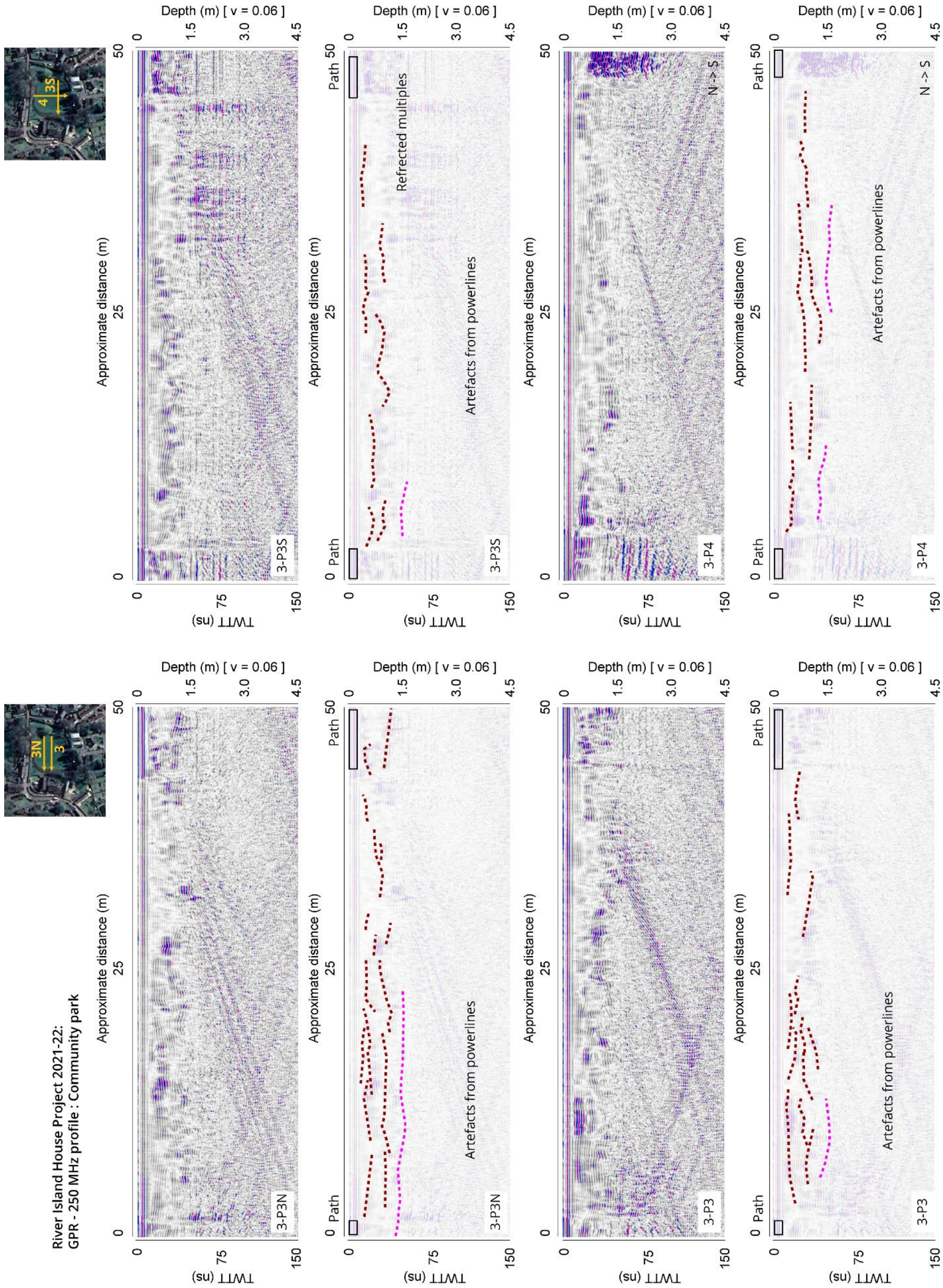


Figure 19: Radargrams and first-pass interpretations for profiles taken with 250 MHz shielded antennae across Cors Field play area running east-west to the north (Profile 3N), top left pair), centre (Profile 3, bottom left pair) and south (Profile 3S, top right pair), and running north-south (Profile 4, bottom right pair). Position and profile orientation shown in uppermost insets.

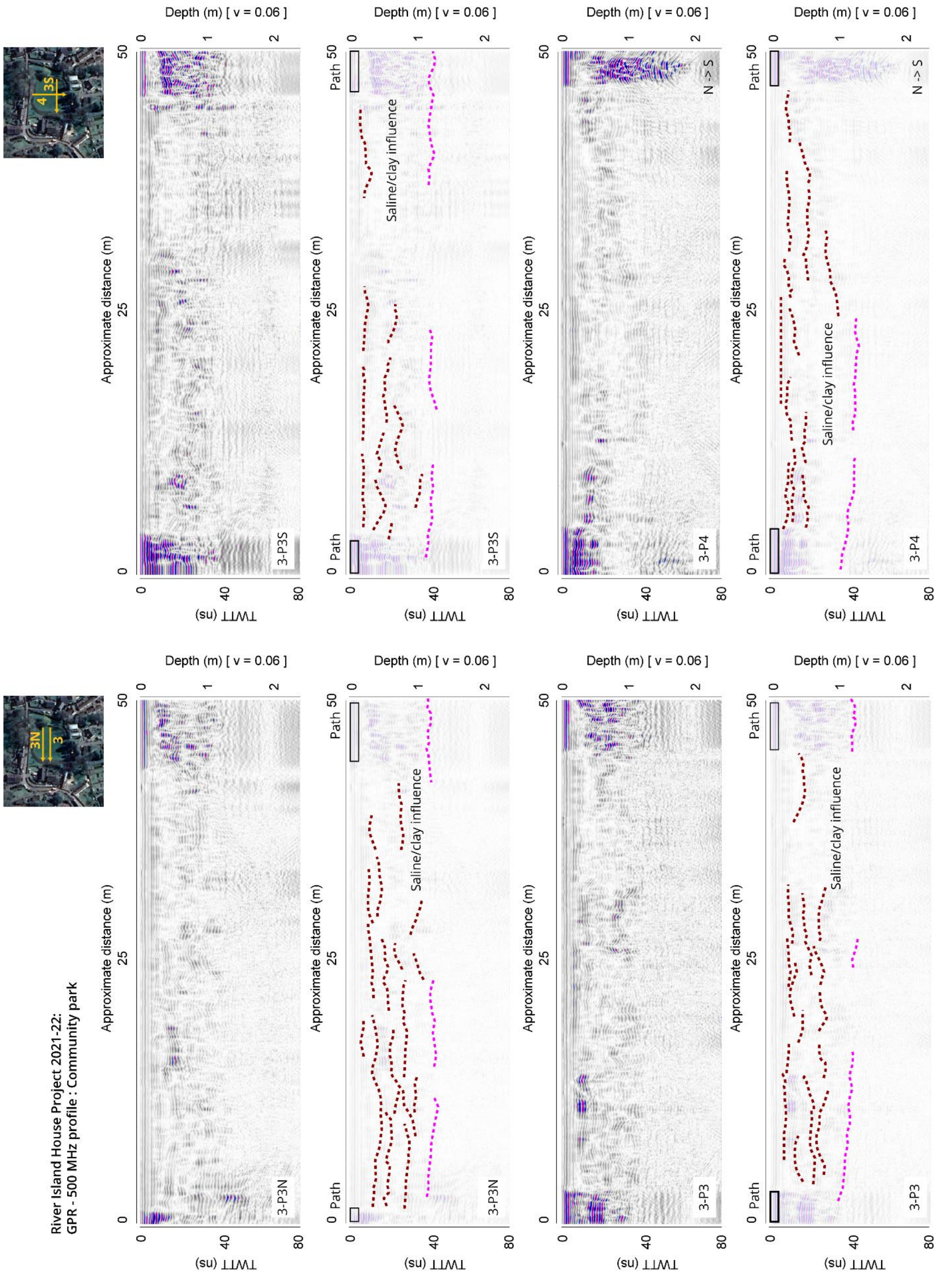


Figure 20: Radargrams and first-pass interpretations for profiles taken with 500 MHz shielded antennae across Cors Field play area running east-west to the north (Profile 3N, top left pair), centre (Profile 3, bottom left pair) and south (Profile 3S, top right pair), and running north-south (Profile 4, bottom right pair). Position and profile orientation shown in uppermost insets.

3.1.5 Profiles 5 - 8: Clifton Street building plot

The area of rough, undeveloped ground lying between the River Coran and Clifton Street exhibited a transition at ~30-50 ns (~0.9 m to 1.5 m) depth in surveys undertaken with 250 MHz and 500 MHz antennae (Figs 21-22). The transition was evident in both the NW to SE and NE to SW oriented profiles. Above this transition, there was evidence of reworked or disturbed ground, but no coherent structures in the near surface. The uppermost zone, with a damping of the radar signal, suggested a more clay-rich sediment unit. There was a dipping surface approximately 30 m from the River Coran, this is most likely a former river bank or terrace front (Fig 22). Below the transition surface, there was evidence of multiple reflections (or resonant scattering), which concealed any deeper sediment structures.

As with the Cors Field play area, the second set of high frequency shielded surveys was more conclusive with clear evidence of subsurface sediment structures in the uppermost 40 ns (~ 1.2 m); a suite of indicative sub-horizontal, non-parallel, dipping reflector surfaces was clear, suggestive of fluvial activity (Figs 23-24). However, this may also suggest sequences of 'infill' potentially by anthropogenic influence and reworking of the ground. Below ~ 1.2 m depth, consistently the radar signal was extinguished, suggestive of clays and/or water saturated sediments influencing the loss of radar energy in the subsurface.

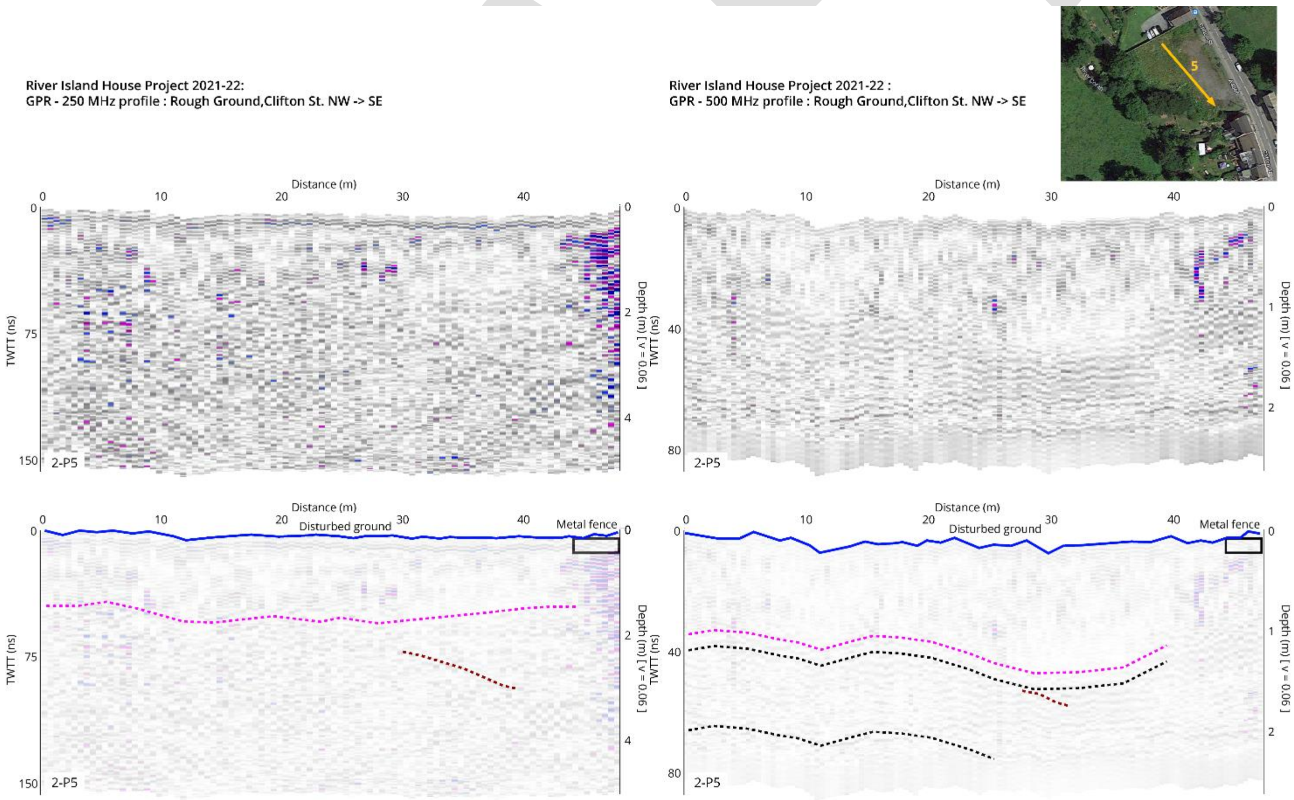


Figure 21: Radargrams and first-pass interpretations for north-south Profile 5 across rough ground area at Clifton Street building plot for 250 MHz (left pair) and 500 MHz (right pair) shielded antennae. A coarse sampling strategy was employed given concerns over integrity of site and potential for reworked surface materials. Position and profile orientation shown in upper inset.

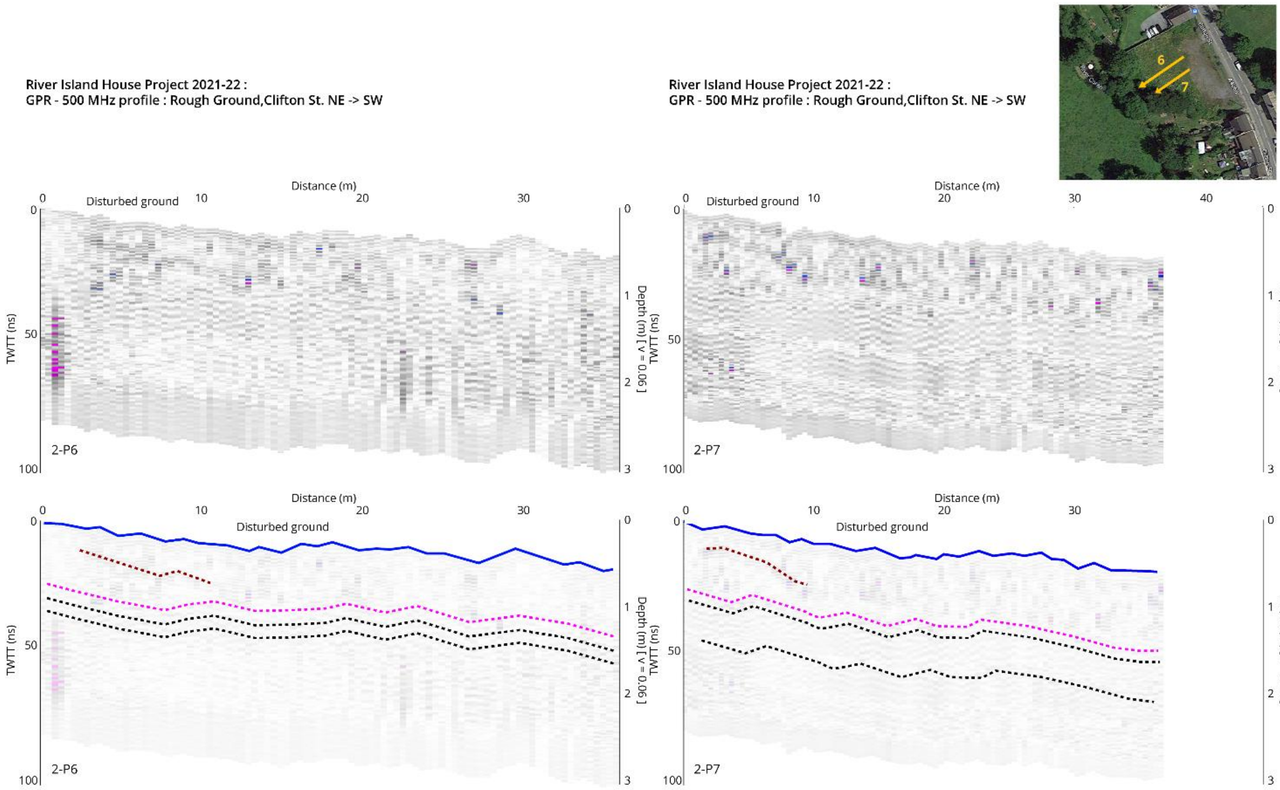


Figure 22: Radargrams and first-pass interpretations for parallel east-west Profiles 6 & 7 taken with 500 MHz shielded antennae across rough ground at Clifton Street building plot. A coarse sampling strategy was employed given concerns over integrity of site and potential for reworked surface materials. Position and profile orientation shown in upper inset with the northern profile data shown on left, and the southern profile on right.

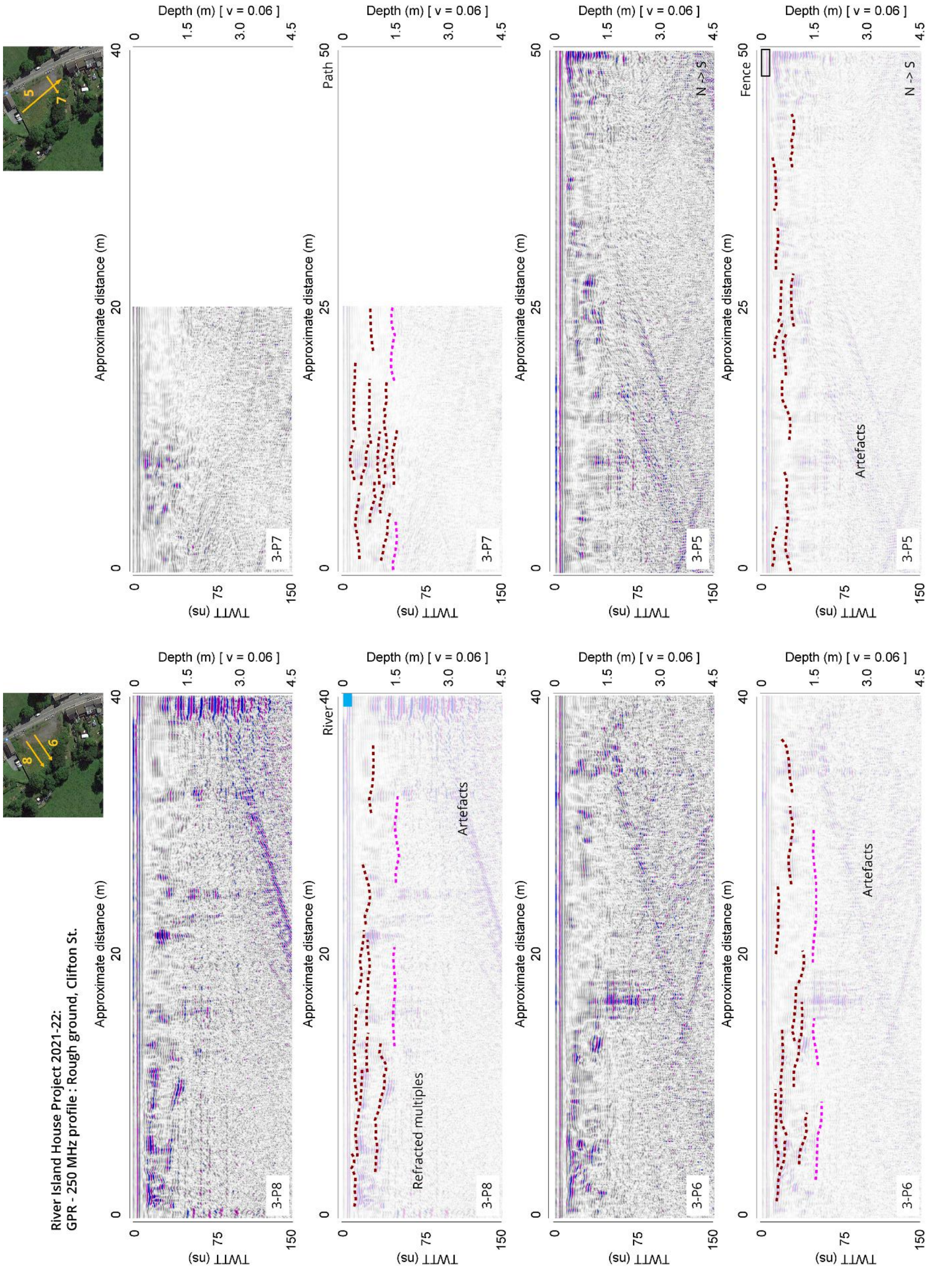


Figure 23: Radargrams and first-pass interpretations for profiles taken with 250 MHz shielded antennae across rough ground area at Clifton Street building plot running east-west to the north (Profile 6, top left pair), centre (Profile 8, bottom left pair) and south (Profile 7, top right pair), and running north-south (Profile 5, bottom right pair). Position and profile orientation shown in uppermost insets.

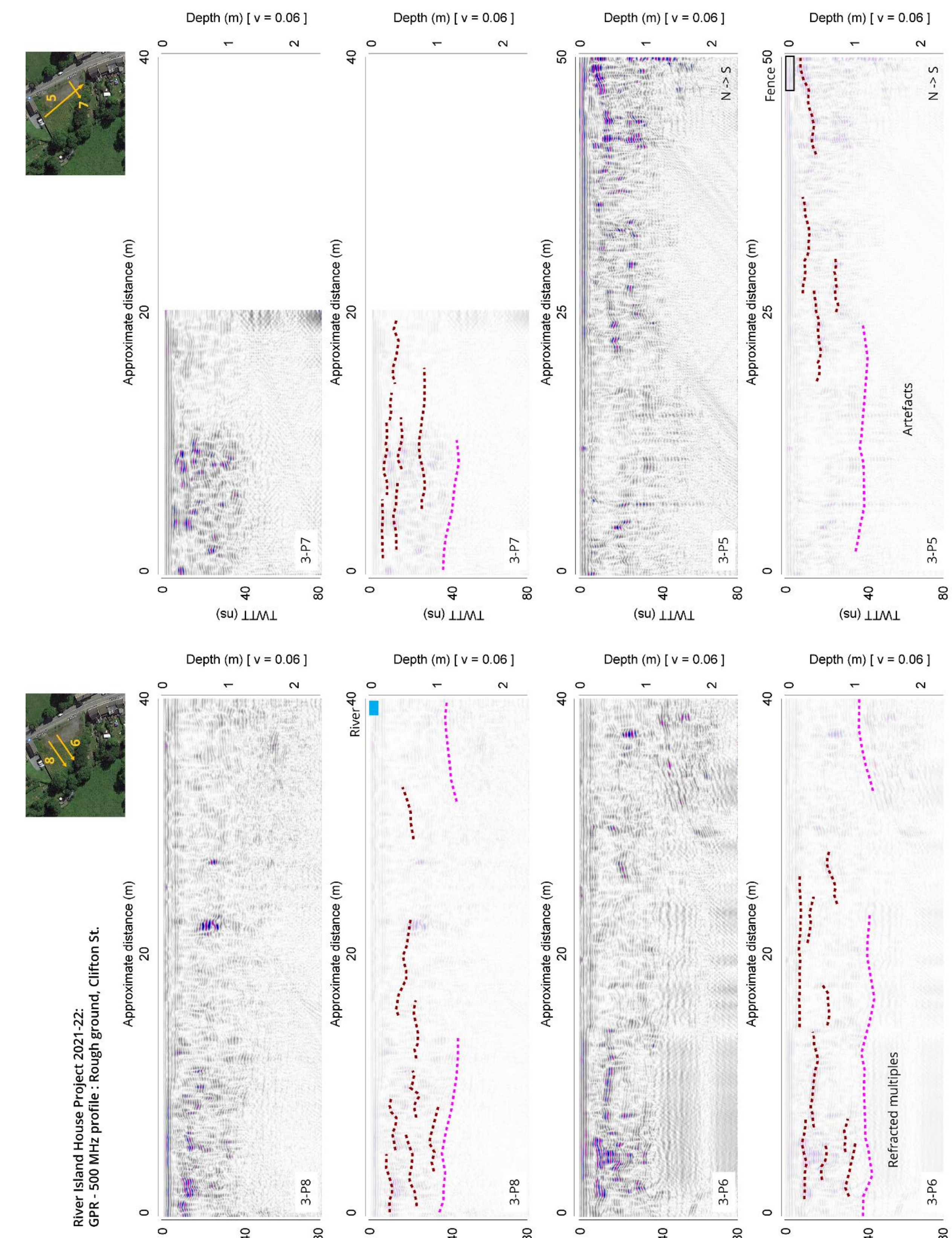


Figure 24: Radargrams and first-pass interpretations for profiles taken with 500 MHz shielded antennae across rough ground area at Clifton Street building plot running east-west to the north (Profile 6, top left pair), centre (Profile 8, bottom left pair) and south (Profile 7, top right pair), and running north-south (Profile 5, bottom right pair). Position and profile orientation shown in uppermost insets.

3.1.6 Profiles 9 – 12: Island House perimeter wall (Town Wall)

Paired surveys (250 MHz and 500 MHz) were conducted around the perimeter of the Island House compound (Fig 25). Profile lines were run around the exterior of the River Island House compound, proximate to the existing perimeter wall (and identified with 'i' for an inner position) and closer to the roadways (identified with 'o' for outer position). The location is heavily impacted by human structures and features so a CMP survey was not conducted here (Section 2.4.2), this means the radargrams have a higher degree of uncertainty in term of depth estimates. Nevertheless, depth was estimated using a velocity of 0.06 m/ns for sediments, and for visible tarmac/asphalt surface and/or assumed gravel hardcore substrates a velocity of 0.14 m/ns was used. The surveys were also influenced by the presence of man-made features (including drains, manholes, signs, bollards, metal-framed benches and their concrete foundations).

There was some evidence of an interface at 0.3 – 0.7 m depth; it is unclear if this relates to an oblique offline return from the existing wall and/or its foundation, or the limit of the tarmac/asphalt unit and its substrate. In the profile extending southward from Island House across the car-park, this interface shows a marked change, becoming shallower across much of the car-park. Discrimination of other subsurface structures was not feasible owing to the interference generated by the surface features, and their likely shallow near-surface foundations. The surveys did pick out possible underground drainage pipes or wires.

In all cases, the issue of radar signal extinction at depths below 40 – 60 ns (> 1.2 m) mirrored that seen at other sites, suggestive of clay-rich / saturated sediments attenuating the energy in the upper sediment unit, and/or the rapid extinction of the radar signal at depth.

3.1.7 Profiles 13 – 16: Within the Island House site

Despite attempting to survey within the Island House compound itself (profiles oriented both north-south and east-west; Figure 3), the presence of metallic objects at the surface (e.g. fencing, scaffolding, tools, equipment, shipping containers), electrical cables, and the relative proximity of old and recent foundations, walling, and varied terrain arising from excavation, resulted in poor quality radargrams. Unfortunately, no interpretation was possible for the subsurface within the compound's limits and so radargrams are not presented in the main report.

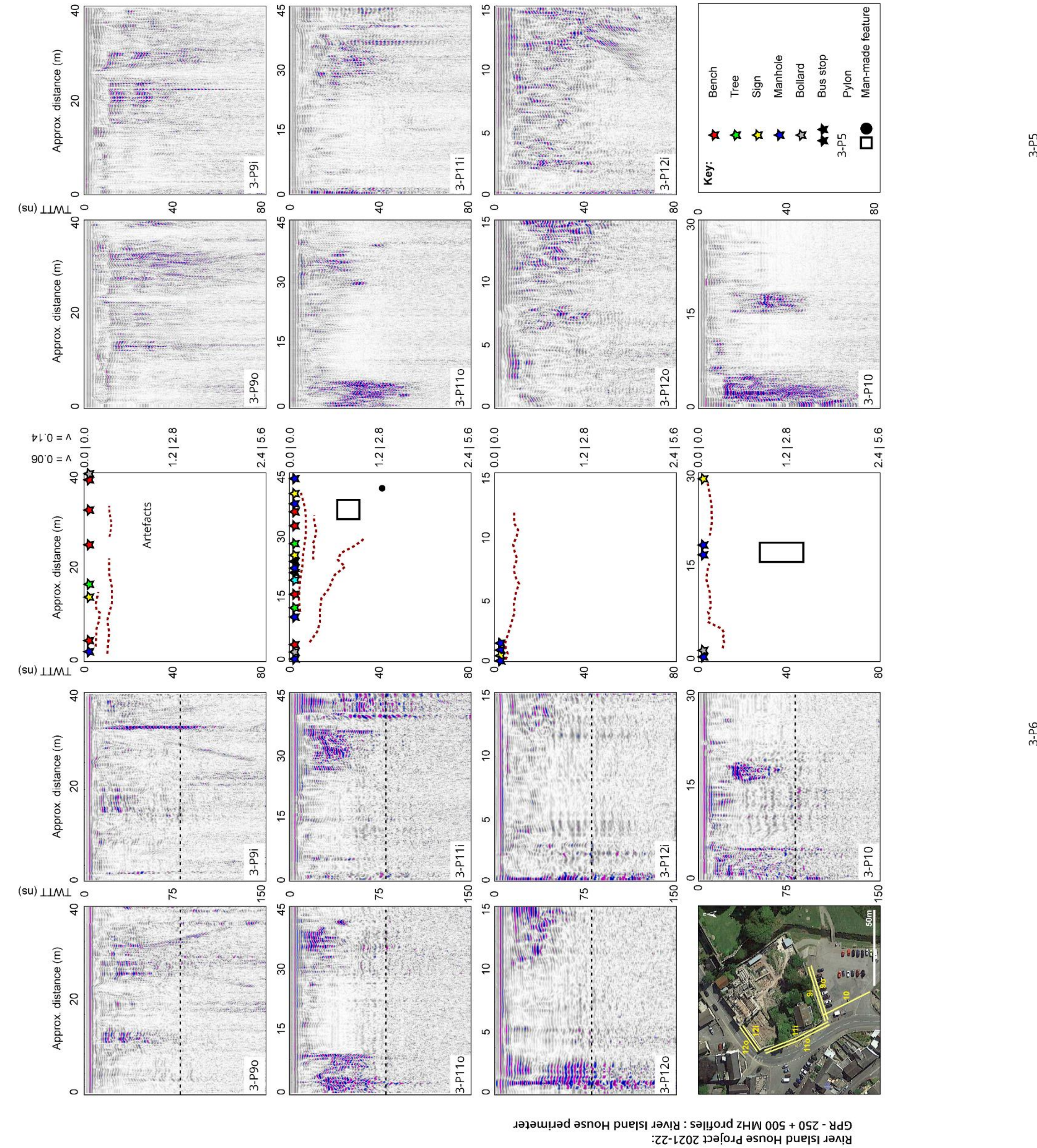


Figure 25 Composite of all 250 MHz (left) and 500 MHz (right) profiles taken around the Island House compound and existing walls. Combined interpretation set, and notes of surface features, shown in central panels. Location of profiles shown in inset to lower left.

3.1.8 Summary of GPR survey findings

The specific nature of the locations accessed in Laugharne resulted in a number of significant challenges for GPR surveying. The use of unshielded antennae to identify sedimentary structures at greater depths was prohibited owing to the propensity for above-ground interference derived from man-made features (walls, power-lines, metal park benches etc.).

The characteristics in the radargrams derived across all the sites surveyed suggest that the near surface is characterised by two primary sediment units: an upper unit, most likely extending to around 1 - 1.5 m depth as a maximum depth (±10%) and a lower saline or clay-rich unit below, which extinguished the radar signal. Interpretation of subsurface structure below the 1.5 m transition depth was challenging.

In the uppermost sediment unit, there is evidence of saline or clay-rich sediment zones. This was best illustrated south of the castle, close to the River Coran and approaching the salt marsh, as well as in discrete areas within the Cors Field play area and Clifton Street building plot.

In the uppermost sediment unit, there is some limited evidence of reworking or disturbance of the uppermost sediment unit, particularly close to the southernmost extent of the Laugharne Castle wall. At the other sites, adjacent to the River Coran, subtle subsurface indicators suggest fluvial sediment structures that may reflect potential variation in the River Coran's position in the past, with topographic depressions being infilled either through channel migration or by tributary streams no longer present. However, these indicators may also arise from more recent human activity reworking the ground both at the Cors Field play area and Clifton Street building plot locations.

The surveys within and around the Island House compound were made challenging owing to the number of man-made features (cabling, metal machinery, metal fencing, manholes, drains, metal-framed park benches etc.). There were no clear and definitive indications of archaeological features relating to Island House readily determined from this GPR assessment around the compound perimeter.

3.2 Radiometric ^{14}C dating

Following sediment logging within the footprint of Island House in August 2021, 5 organic material samples were submitted to the Radiocarbon Dating Facility, Queens University, Belfast for ^{14}C dating. The July 2022 coring programme yielded a further 4 shell/wood samples, these were submitted to BetaAnalytic for ^{14}C dating. Table 3 summarises the calibrated dates and stratigraphic context for each sample.

Table 3: Summary of ^{14}C dates

Sample (code)	Site	Depth (cm)	Calibrated age	Notes
Oak beam 1 (UBA-45962)	n/a	n/a	1509-1793 cal AD median probability of cal AD 1568	Dendrochronology date: AD 1657
Oak beam 2 (UBA-45963)	n/a	n/a	1434-1475 cal AD median probability of cal AD 1444	Dendrochronology date: AD 1437
Charcoal (UBA-45965)	Log 1	140	Invalid age	53,991 +/- 5436 years outside the acceptable range for ^{14}C. Likely contamination with 'old' carbon.
Charcoal (UBA-45966)	Log 1	155	Invalid age	11,485 +/- 43. Likely contamination with 'old' carbon.
Shell (UBA-45964)	Log 1	175	1099 +/-105 cal AD	50% marine reservoir effect correction applied to original radiocarbon age: 1150 +/- 19 [Delta R = -141.0 +/- 54.0]
Shell (WS02) (Beta 636572)	Core WS02	218-231	1278-1577 cal AD	50% marine reservoir effect correction applied to original radiocarbon age: 590 +/- 30 BP [Delta R = -141.0 +/- 54.0]
Shell (WS02) (Beta 648688)	Core WS02	375	264-632 cal AD	50% marine reservoir effect correction applied to original radiocarbon age: 1600 +/- 30 BP [Delta R = -141.0 +/- 54.0]
Plant material (WS03) (Beta 63673)	Core WS03	434-436	224-376 cal AD	
Plant material (WS03) (Beta 63674)	Core WS03	518-520	324-418 cal AD (75.5%) 254-288 cal AD (19.9%)	

Two samples were taken from oak beams which had already been independently dated using dendrochronology (Stephen Kirkwood, *pers comm*). Interestingly, the ^{14}C and dendrochronology dates for oak beam 2 are indistinguishable (mid 15^{th} century), and the dendrochronology date for beam 1 lies within the error margin of the ^{14}C date (mid 16^{th} – mid 17^{th} century). These dates suggest that the beams were either recovered from parts of the building constructed at different times, or that there had been some mid $16^{th}/17^{th}$ repair work (beam 1) to an older (mid 15^{th} century?) part of the building (beam 2).

The dated shell and wood fragments from Log 1, Core 2 and Core 3 (Table 3) are considered in sections 3.3 and 3.4, and then discussed further in section 4 (Environmental History Reconstruction).

3.3 Sediment Profile Logs

Figures 26-29 show sediment logs from the four exposed profiles within the Island House site. Each sediment log is divided up into a series of columns from left to right showing:

1) Depth (m) from the ground surface
2) Lithology and grain size (mud/sand/gravel) of each sediment unit
3) Presence of fossils (e.g. wood/shells)
4) A description of each sediment unit depth
5) Dates (if available)

Figure 26 contains the most detailed sediment stratigraphy and the highest number of dates (archaeological). At the base of the section (> 175cm) are clast-supported well-rounded gravels which are interpreted as R. Coran channel sediments. This sediment unit is at a similar elevation to the present-day River Coran suggesting relative vertical channel stability over the last 100 years or so.

Immediately above the channel gravels (166-175) are grey silts/sand containing shells (dated to cal AD 1099 +/- 105); this unit contained $13^{th}/14^{th}/15^{th}$ pottery. The artefacts, and possibly the shell fragments, are probably the earliest evidence human activity at the site. The sediments themselves are likely to be a combination of estuarine silts and fine-grained overbank river sediments, indicating that the main channel had probably laterally migrated from the position it held when the underlying well-rounded gravels were deposited.

Above this unit are further couplets of river channel gravels (160-166 cm; 112-138 cm; 76-103 cm, indicating that the Coran channel is intermittently migrating across the site, or that rivers bars are forming on its margins), and fine-grained sandy silts (153-160 cm; 138-144 cm; 103-112 cm). A small sample of oxidised copper was recovered at 160 cm between fragments of charcoal at 155 and 140 cm. The charcoal dates were unexpectedly old due to the presence of 'old' carbon. This suggests that human activity/occupation at the site probably involved burning wood and coal, old carbon in the coal mixed with young carbon from wood produced these unreliable dates. However, we know from archaeological artefacts that the sediments in this part of the profile date between the 13^{th} and 15^{th} centuries. The presence of enriched (>2%, and up to 20%) oxidised copper at 155 cm could indicate early metallurgical activity (e.g. bronze manufacture).

The top 76 cm of the profile comprise silt rich sediments with occasional gravel clasts, these are likely to be fine grained flood sediment from the River Coran rather than estuarine sediments. Near the top of the section (26-57 cm) a wine bottle was dated to the 18^{th} century.

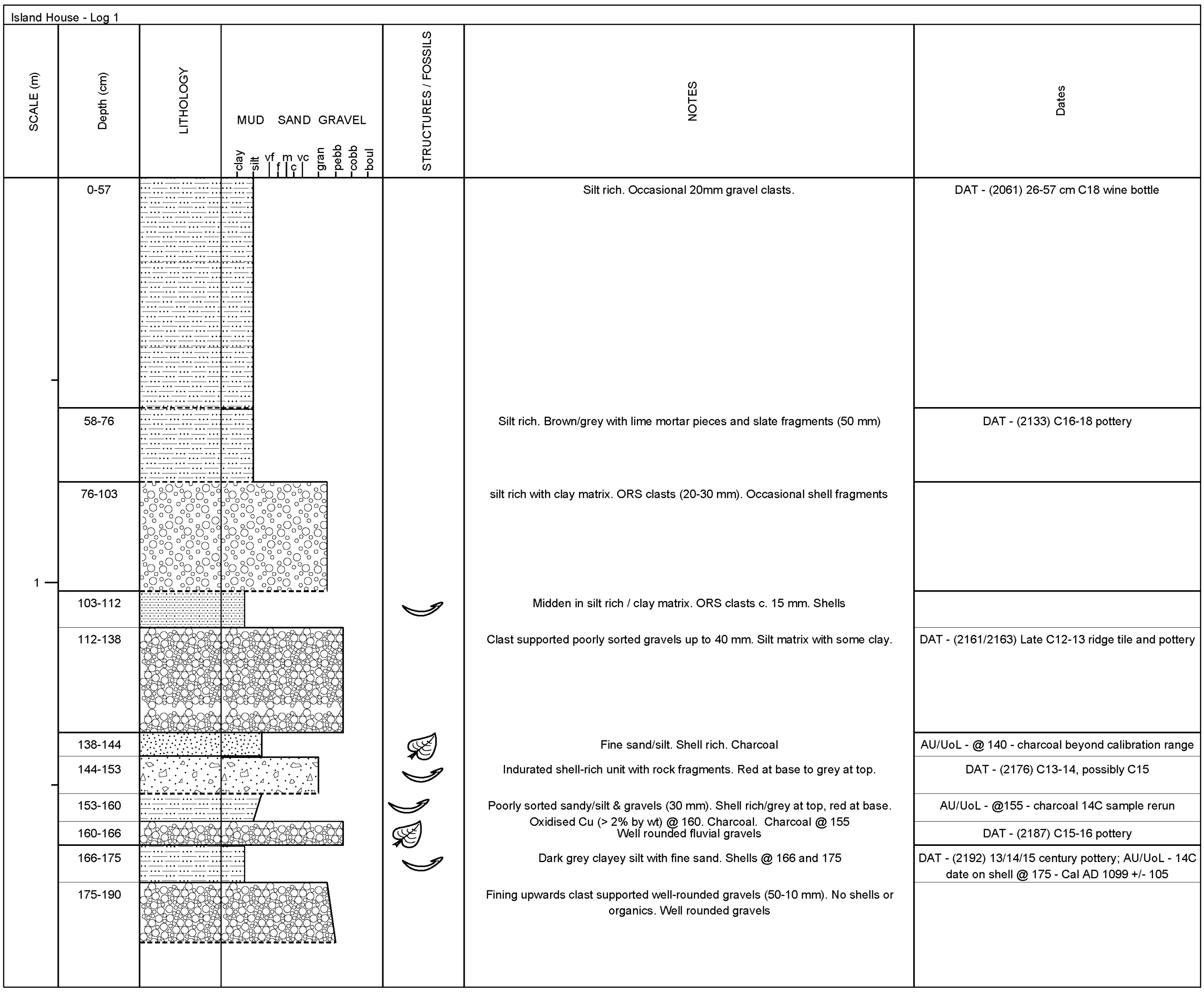


Figure 26 – Sediment profile log 1 stratigraphy and dates. In the final ‘Dates’ column, DAT indicates dating information from Dyfed Archaeological Trust (2020), and AU/UoL refers to ^{14}C dates secured through this study. Log 1 is located against the north Island House boundary wall, this profile was also logged by Dyfed Archaeological Trust (see Figure 1).

The other 3 sediment exposures (Logs 2-4) within the footprint of Island House comprise similar sediments to Log 1, but the sequence is considerably less complex (Figures 27-29). Sediment Log 2, located to the south of Island House on the right bank of a former channel has in excess of 60 cm of fluvial gravels at its base (Figure 27); these are directly analogous to the river channel gravels identified in Log 1 (Figure 26). Overlying these gravels is a thick shell midden (58-88 cm) that again correlates with an equivalent deposit in Log 1 (144-153 cm). Overlying this is a silty unit rich with bone fragments and angular clasts which matches with the capping sediments in Log 1(0-76 cm).

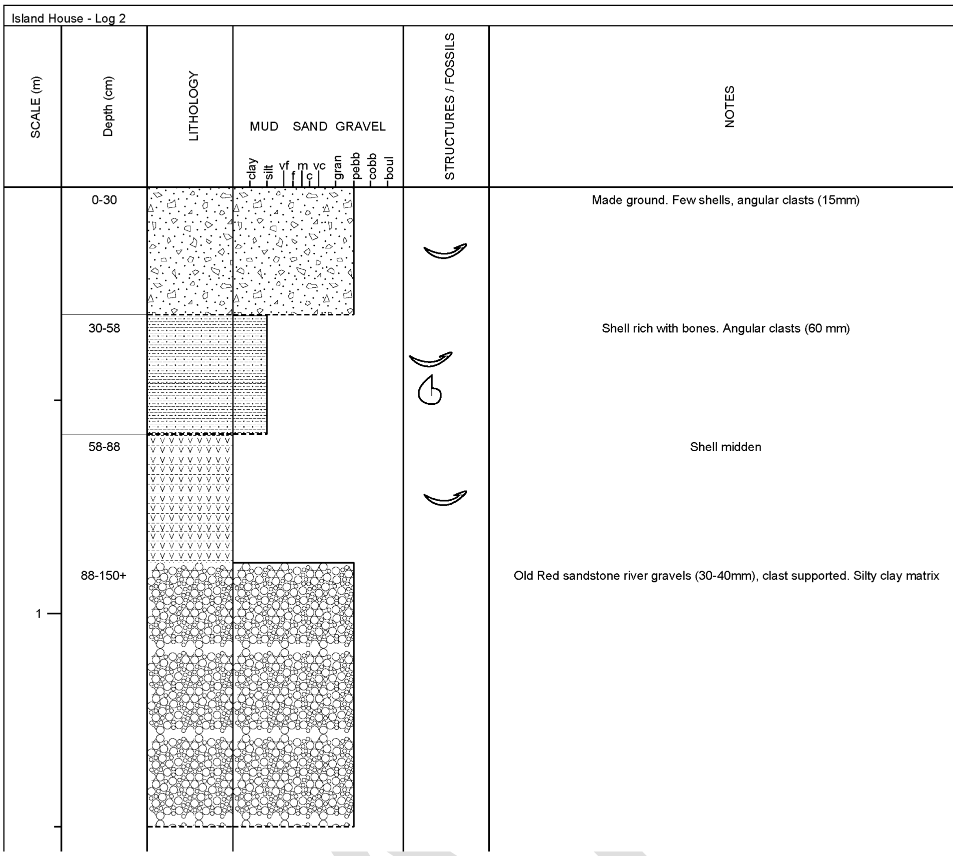


Figure 27 – Sediment profile log 2 stratigraphy. Log 2 is to the south of Island House on the right bank of a former channel (see Figure 1).

Logs 3 and 4 are located on the west and east boundary margins of the site, respectively. Both logs 4 are underpinned by at least 50 cm of river gravels demonstrating the spatial extend of this unit which almost certainly formed a major bar/island in the lower Coran River. The gravels in both exposures are overlain by several finer-grained sediment units containing occasional shells and/or charcoal flecks. These sediments are most likely to be fine grained overbank flood deposits sourced from the River Coran. Log 3 (Figure 28) contains an additional gravel unit (109-117 cm), given the proximity of the sediment section to the River Coran this is almost certainly a major flood deposit sourced from the Coran. Although Log 3 contains a shell rich [midden] unit (78-109 cm) Log 4 does not, suggesting that the area closest to the current bungalow was not used as a waste dump or for shellfish processing.

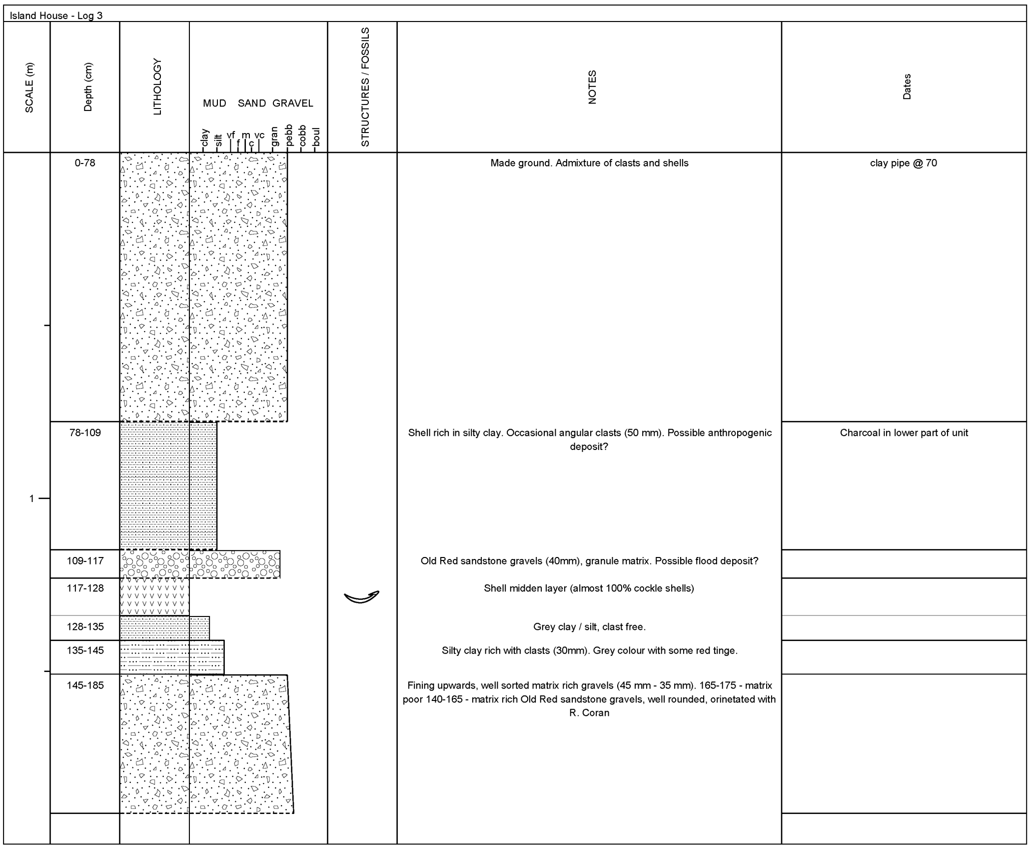


Figure 28 – Sediment profile log 3 stratigraphy. Log 3 was from an open pit adjacent to the west boundary wall with the bungalow (see Figure 1).

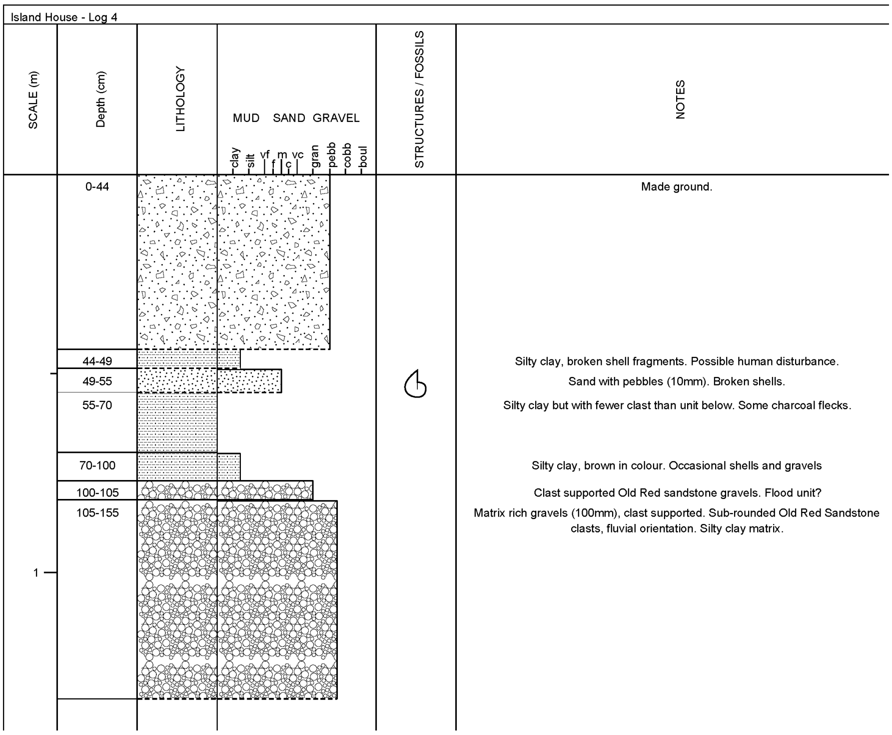


Figure 29 – Sediment profile log 4 stratigraphy. Log $ was from an open pit adjacent to the east boundary wall / R. Coran (see Figure 1).

3.4 Sediment Core Logs

Figures 30-32 show sediment stratigraphy obtained from the two saltmarsh cores (WS01 & WS02) and the Clifton Street building plot (Core WS03).

The upper sediment units in the 5 m long Core WS01, close to the east bank of the River Coran (Figure 2), bare many similarities to those found in the four sediment exposures (Logs 1-4) within the footprint if Island House. Between 86-180 cm there is a thick unit of river gravels that correlates with similar basal gravel units in Logs 1-4. The overlying stratigraphy of Core WS01 broadly matches that of Log 4, in particular the presence of a fine gravel flood unit (41-54 cm) derived from the River Coran. Lying beneath the major River Coran channel/bar sediment unit (86-180 cm) is an alternating sequence of grey clay/silt and gravel units. The former are saltmarsh sediments and the latter River Coran channel/bar sediments. This alternating pattern of coarse and fine grained units indicates that at this particular core location, the River Coran was most likely switching its course from west to east and then back again, resulting in sedimentation being dominated by either river sediment or by estuarine/saltmarsh sediments.

Core WS02 (5.9 m long), whilst also being located on the saltmarsh, lies 250 m to the NE of Core WS01 and so is unlikely to be influence by sediments from the River Coran. The stratigraphy of Core WS02 is markedly different to that in Core WS01, most notably because it is almost entirely dominated by silt and clay sized sediment (Figure 31). There is a general trend for sediment to fine up core, i.e. at the base there are silty fine sands (> 390 cm), often containing shell fragments, which indicate deposition under estuarine conditions. At the top of the core (< 189 cm), sediments have progressively fined to silty clays with plant matter/roots replacing shells. These sediments are clear evidence of a shift to a saltmarsh environment. The presence of shells fragments afforded the opportunity to obtain two ^{14}C dates (Table 3): 264-635 cal AD (at 375 cm) and 1278-1577 cal AD (between 218-231). The significance of these dates to the environmental history of the estuary is discussed in the final section of this report.

The 5.6 m long Core WS03 was recovered from in the Clifton Street building plot site (Figure 2). Its sediment sequence differs from the two cores recovered from the saltmarsh in that it comprises entirely freshwater material. The lower half of the core (>222 cm) is dominated by a series of brown/grey clay units, often containing organic material (leaves, wood). Two samples were sent to BetaAnalytic for ^{14}C analysis, they returned dates of 254-288 / 324-418 cal AD (518-522 cm) and 224-376 cal AD (425-437 cm). These sediments are indicative of backwater, wetland or lacustrine (lakes) environments and suggest that in the early centuries of the first millennium AD this site was possibly a lake or wetland. This type of environment may have persisted for many centuries and could account for the naming of the nearby 'Horsepool Road'. The broader significance of these dates to the environmental history of the lower River Coran is discussed in the final section of this report.

Above c. 375 cm the amount of organic matter declines and sediments become more silty in nature. This suggests a transition towards sediment deposition in a floodplain environment, more akin to what is presently seen at the site. Between 210-222 cm is a disturbed organic rich layer containing some coarse granules. It is possible that this unit marks the beginning of anthropogenic disturbance because above this the there is increasing evidence concrete in the sediment stack, albeit intercalating with fluvial sediments (e.g./ 50-57 cm, 100-130 cm, 146-162 cm).

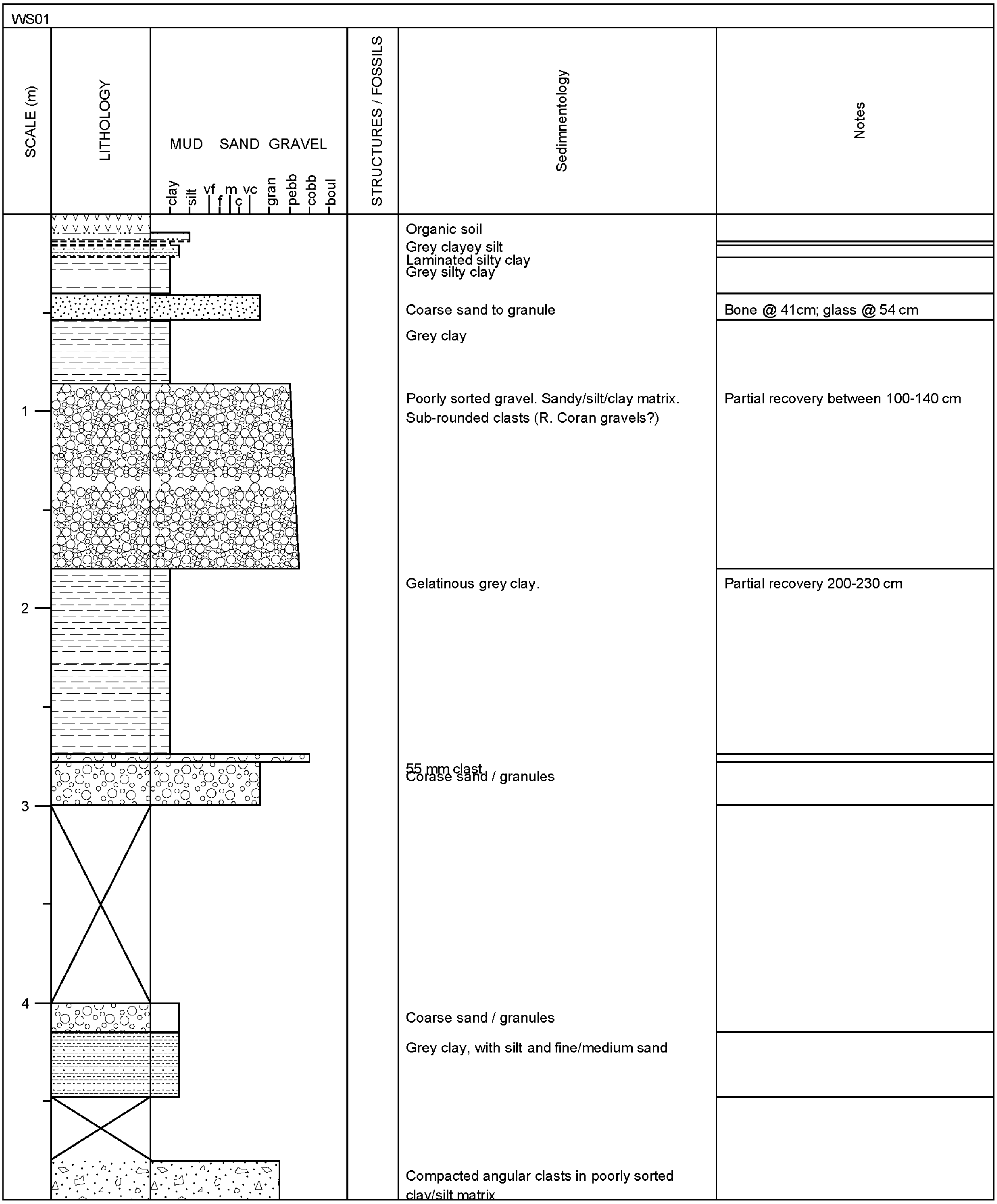


Figure 30 – Core WS01 sediment log stratigraphy (no dates obtained). Core 1 is located on the salt marsh foreshore, south of the castle walls and east of the R. Coran (see Figure 2).

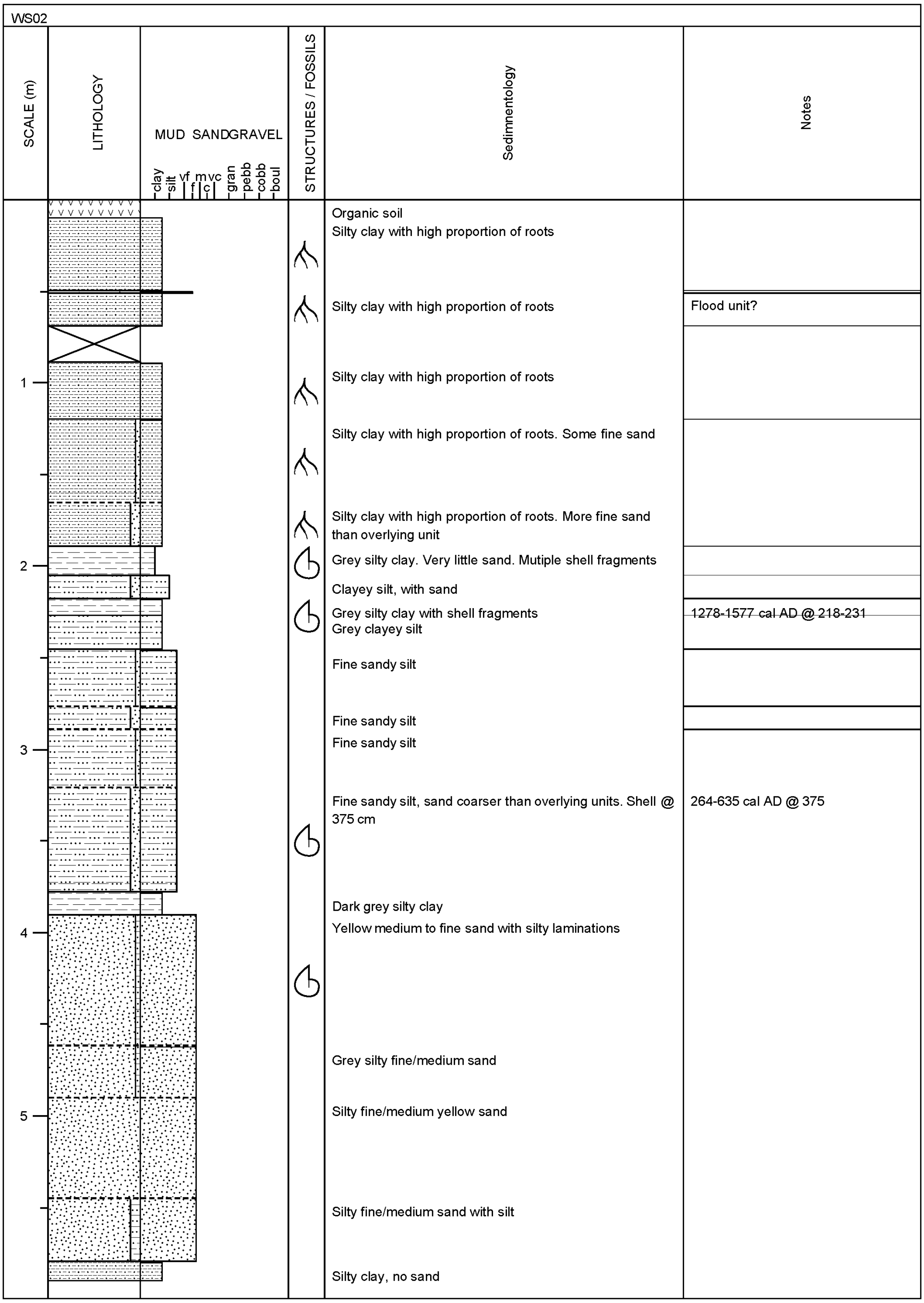


Figure 31 – Core WS02 sediment log stratigraphy and dates. Core 2 is located on the salt marsh foreshore east of the castle walls (see Figure 2).

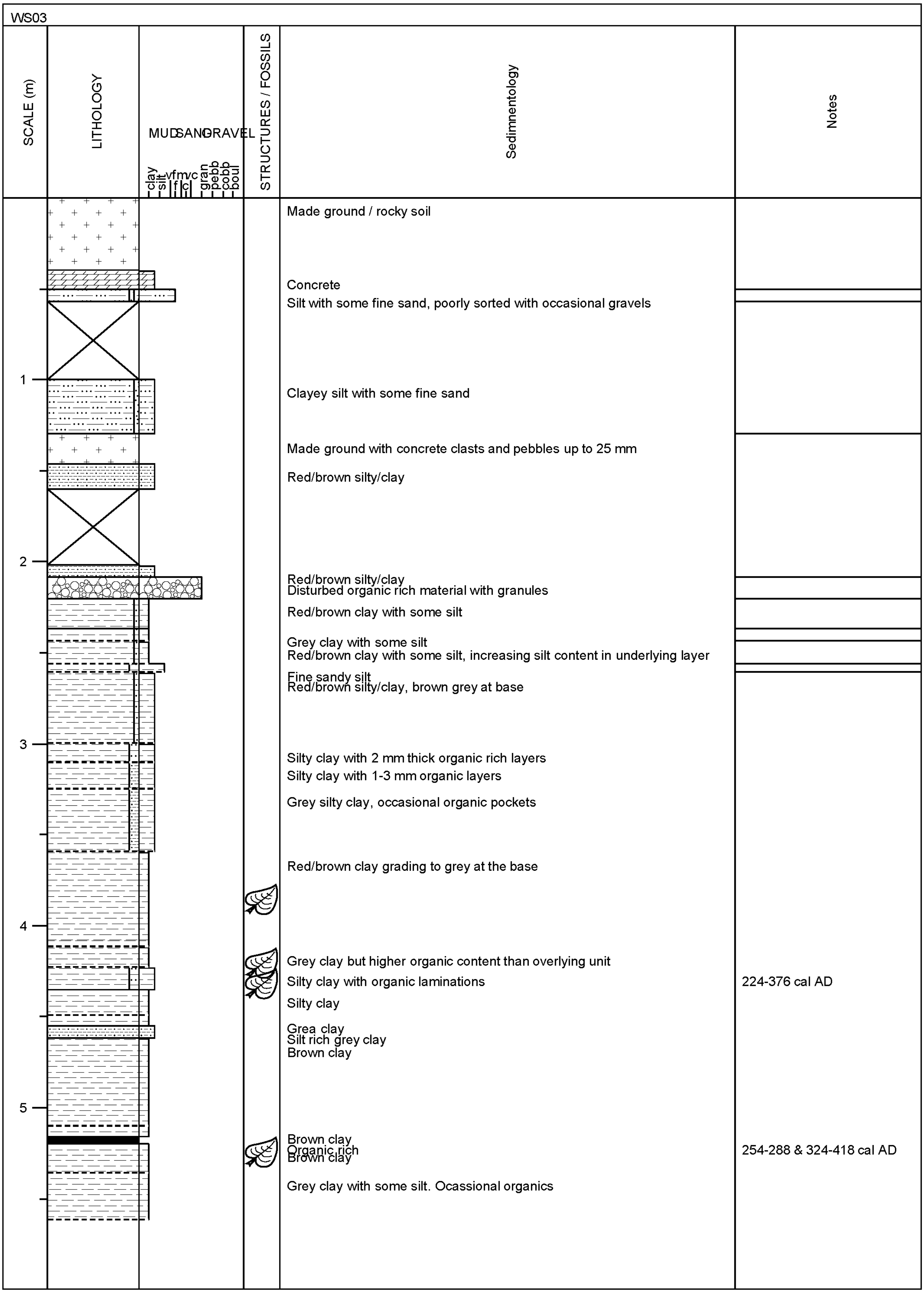


Figure 32 – Core WS03 sediment log stratigraphy and dates. Core 3 is located on the Clifton Street building plot east of the R. Coran (see Figure 2).

4) Interpretation – environmental reconstruction of Island House and its environs

From archaeological trenches dug within the Island House boundary (Island House Logs 1-4), and from sediment cores collected at the mouth River Coran (WS01), in lower and non-tidal reaches of the River Coran adjacent to Clifton Street (WS03), and in the present saltmarsh immediately south of Laugharne Castle (WS02), it is possible to reconstruct a history of river and estuarine deposition since the early-middle 3rd century AD in and around Island House. Five radiocarbon dates, along with age diagnostic ceramics recovered within the former channel on the southwest side of Island House (Log 1), enable the impact of changing river dynamics and estuarine sedimentation on settlement in late Antiquity/early medieval period through to the 18th century AD to be assessed. This includes the periods of construction, use and partial abandonment of Laugharne Castle as well as Island House itself.

The oldest radiocarbon ages of 254-418 cal. AD and 264-632 cal. AD were recovered from cores WS03 and WSO2, respectively. These demonstrate that there has been c. 5.25m of river aggradation in the lower River Coran, and 3.75m of marine sedimentation in the Taf estuary immediately adjacent to Laugharne Castle in the last 1700-1300 years. The period 224-418 cal. AD was characterised by rapid sedimentation (c. 1m in less than a century) in the lower Coran valley. It is noteworthy that there is a change in sediment type (from clay to sandy silts containing mussel shells) in Taf estuary in 3rd to 7th century AD suggesting a period of major river flooding and sea-level rise in the Laugharne area towards the end of the Roman occupation and continuing during the early medieval period. A marked increase in river activity and channel change is also more widely recorded in central and south Wales during this period, linked to a colder and wetter climate (Jones et al., 2010; Macklin et al., 2010).

A second radiocarbon age – 1278-1577 cal. AD – in core WSO2 at a depth of 2.25m shows that rates of estuarine sedimentation at Laugharne increased by a factor of two in the last 700-400 years (3.3-6.0 mm yr^{-1}) in comparison with the late Roman and earlier medieval periods (1.1-2.3 mm yr^{-1}). This is also mirrored by deposition of approximately 1m of gravels and sands in a former channel of the River Coran on the southwest side of Island House (Log 1) between the 12th and 16th centuries AD. The prominent river gravel unit at c. 0.9-1.75m depth in core WS01 at the mouth of the tidally-influenced River Coran is likely to be a continuation of that exposed in Log 1 described above. There is a progressive reduction in grain size up section in both the estuarine core (WS02) with a shift from sand, silt to clay, and in the tidally-influenced reach of the River Coran (WS01) with a switch from gravel to clay. This is likely to reflect a significant increase in finer-grained sediment (clay-rich; see core WS03 from the non-tidal reaches of the River Coran) derived from river catchment sources that seems to have taken place sometime shortly after the late 13th to late 16th centuries most probably associated with farming activities and woodland clearance (Macklin et al., 2014).

Immediately prior to the construction of the buildings identified and dated by DAT Archaeological Services to the 13th to 15th century AD within the present walls of Island House, subsurface and sedimentological data indicate that the River Coran was formed of two channels that divided around a small gravel island on which the main part of the present Island House was constructed. It is very likely that this topographical feature gave the name to the building. This delta-like shoal of river gravel, probably with multiple channels, would have provided a convenient crossing point at the mouth of the River Coran as well as an area at which shallow draft boats could have been beached. As demonstrated from industrial and food waste preserved in both former river channels underlying Island House (Logs 1 and 2), this area was a focus of metal working and shell-fish processing in the 12th- 13th centuries, which continued to be used for waste disposal during and after the construction of buildings on this site during the 13th-15th centuries.

The seaward slope of these gravels, and the relatively steep river gradient at this point, do not support the reconstruction of a large tidal inlet on the western side of Laugharne Castle in the mid-twelfth to the mid-fourteenth centuries, as recently proposed by DAT Archaeological Services (2021). The slower sedimentation rates recorded in core WSO2 from the late Roman/early medieval period until the late 13th century would suggest a more open beach and estuarine environment, facilitating access by boat to Laugharne Castle, certainly in its earlier phases. However, within a generation of the de Brian's transforming the castle into a major stronghold during the second half of the 13th century, sedimentation rates on the Laugharne foreshore doubled because of increased erosion and sediment delivery from the Coran catchment. This undoubtedly would have curtailed larger ships, sailing up or down the Taf estuary, reaching both Laugharne Castle and the town itself.

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